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TABLE OF CONTENTS.

	Page.
LEADING ARTICLES:	
Line Changes and Extensions by the Oregon Railroad and Navigation Company's System in Oregon and Washington (illustrated); W. P. Hardesty..	525
Car Wheels for Combined Interurban and City Service (illustrated); C. Skinner	527
The Oakland Bridge, Pittsburg, Pa.; A Steel Arch Without Hinges (illustrated); Willis Whited	528
Train Resistance and the Economics of Railway Location	530
Electricity as a Cause of Fires	534
Improvements on the Chicago Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry.	535
The Philadelphia Trade School	539
Hydraulic Excavation in Seattle with Motor Driven Turbine Pump (illustrated); Geo. D. Moore	540
Hints on Conduit Design (illustrated); Harold Petterson	540
The Bronx Park Derailment on the New York Central. Report of the State Railroad Commission	544
The Construction of the Levee Below the Recent Colorado River Break (illustrated); C. W. Ozias	545
EDITORIAL	541
Alloy Steels—Railway Improvement and Reconstruction—Figuring Rivet Heads or Full Rivets in Estimates of Steelwork—The Death of Chas. H. Haswell.	
The Economics of Railway Location and Railway Train Resistance	542
LETTERS TO THE EDITOR	543
Form for Recording Notes of Preliminary Surveys for a Railway Line; Henry M. Payne—A Novel Method of Facilitating Pile Driving; Ira O. Baker—A Tape Leveling Rod; J. S. Armstrong—Bituminized Dirt Roads at Santa Monica, Cal. (illustrated); Ernest H. Wilcox—Deductions for Punchings and Shearings in Structural Steelwork; Overrun of Shape Steel; A. W. Carpenter—An Engineering Dinner Specification; A. B.	
ENGINEERING NEWS OF THE WEEK	547
PERSONALS	547
ENGINEERING SOCIETIES	548
ENGINEERING LITERATURE SUPPLEMENT	549

LINE CHANGES AND EXTENSIONS OF THE OREGON RAILROAD & NAVIGATION COMPANY'S SYSTEM IN OREGON AND WASHINGTON.

By W. P. HARDESTY, C. E.*

Some radical line and grade changes and several important extensions are being made by the Oregon R. R. & Navigation Co. in Oregon and Washington. This pioneer Oregon railway was first built from Portland up the Columbia River as far as Umatilla in 1881 and 1882, and it was extended on southeasterly to meet the Oregon Short Line Railway at Huntington, Ore., in 1882-1884. Since then many branches have been built and the important extension to Spokane, Wash., has been made, so that at the present time the total mileage of track is 1,258.8. Of this the main line from Portland to Huntington has 404.7 miles.

As the name implies, the company was incorporated to operate on water as well as on land. Though the boat traffic in the early days formed a much more important part of the business than at present, it still is considerable, and about 370 miles of line on the Columbia River and tributaries are covered by the company's steamboats.

During the past two years a large amount of improvement and extension work has been under way. An account of the work recently completed, still under way or authorized for 1907 is given in the following:

TYPICAL SCENERY ON THE COLUMBIA RIVER DIVISION OF THE OREGON RAILWAY & NAVIGATION CO., BETWEEN TROUTDALE AND BONNERVILLE.

LINE CHANGES BEING MADE OR COMPLETED.

TROUTDALE TO BONNEVILLE. — From Troutdale, 18 miles east of Portland, to just beyond Bonneville, is a distance of over 23 miles, and of this 17.48 miles are being changed in one way or another. As the betterments are fairly typical of those being made elsewhere they will be described with some detail.

Going east from Portland the railway line reaches the mouth of the Columbia River gorge four or five miles east of Troutdale, and is then obliged to follow closely along the bank of the river through the gorge. The latter is the opening in the Cascade range through which the Columbia flows. Along this portion of the Columbia, which is justly famed for its scenic beauty, the line runs at the foot of the steep hills on the south, which for much of the distance are nearly vertical basaltic cliffs of great height.

The precipitation in this locality is extremely heavy, amounting at Cascade Locks (midway in the gorge) to about 80 ins. annually. This heavy precipitation and the steep canon sides cause a very rapid run-off at times from the drainage slopes. On occasions during the winter months a heavy fall of snow has resulted in immense snowslides. A spell of mild weather loosens the snowbanks, so that enormous masses fall off the cliffs above or slide bodily down the steep slopes, covering the tracks to great depth. The slides occurring in February, 1907, were particularly bad.

The original location of the railway, very properly for that period, followed closely a supported grade along the river. This necessitated an excessive number of curves, although the general course of the river banks is quite direct. In rebuilding through the gorge the principal aim has been to straighten the alinement. For the most part this is done by building straight across from point to point of the projecting bends, and avoiding the numerous inward curves used by the old line in following near a supported grade at the foot of the hill. At many of the projecting bends, the new line cuts further into the hill than the old one. Most of the new work is in fill, and the borrow is nearly always made by sloping back farther or widening on the uphill side of the cuts. In the standards of construction for new lines, the roadbed width in fills is 18 ft. and in cuts 20 ft. Earth and loose rock cuts here are usually 1 on 1; solid rock is generally taken out at ½ to 1, never steeper than ¼ to 1.

On the Troutdale-Bonneville section the total saving in distance effected in the 17.48 miles is 950 ft.; the reduction in curvature is 1,454° 51', and the saving in grade climb is 25.58 ft. The maximum curve is reduced from 10° to 3°. The maximum grade on the old line was 0.51%, except in a rock cut at east end of the division—one-half mile east of Bonneville—where it was 1%. This latter was reduced to 0.35%, and the maximum retained elsewhere.

The greatest deviation of the new line from the old one is about 450 ft. In many cases one tangent is made to replace several curves, and in one case the new tangent replaces eight curves — though nowhere deviating more than about 75 ft. from the old line.

The largest single fill contains about 63,000 cu. yds., being 2,200 ft. long and 22 ft. maximum height. The heaviest rock cut contains about 24,000 cu. yds., of which 90% is solid rock. This cut is about 600 ft. long and has a maximum depth of 40 ft. In places the new roadbed fills across slight bends of the river, in which case the heavier broken rock is used next to the stream.

About 23½ miles from Portland is located Tunnel No. 1 of the railway, which cuts through a high rock point whose vertical face comes directly down into the river. The present line passes through here with a 600-ft. tunnel, over half of which is on a 10° curve. The new line will strike from 30 to 90 ft. back from the river. The whole length of 655 ft. is taken up by a 2° curve and its spiral. The tunnel is to be constructed according to the standard plans. These call for an inside section of 17 × 23 ft., with 10 × 14 timbers, with a 3-segment arch.

All excavation and loading on this division is being done by steam shovel. The grading contractor is the Pacific Coast Construction Co., of Portland. The work on the Troutdale-Bonneville division, and also that at Hood River,

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Pendleton and some other places, is in charge of Mr. O. Winningstad, Assistant Engineer. In March, 1907, it was about one-third completed.

HOOD RIVER CHANGE.—This line change is being made at the crossing of Hood River, 66 miles east of Portland. It is 3,997 ft. long and it reduces distance by 128 ft. and curvature by 113° 41'. The maximum curvature is reduced from 10° to 2°, and the maximum grade from 0.422% to 0.24%. A new bridge was built across Hood River and is almost directly alongside the old one. It has one 150 ft. through riveted truss span and two 60-ft. deck plate girders. In this, as in all the new bridge work, the piers and abutments are of concrete.

SUMMIT CHANGE.—This change is being made between Dalles and Celilo, at about 95 miles east of Portland. It may here be said that the Dalles, 88 miles from Portland, is the head of the Columbia River gorge, and that above here the canon opens out into the semi-arid plateaus of eastern Oregon, distinct in climate and topography from the portion west of the cascades.

Shortly beyond the Dalles the old line climbs to the top of a slight plateau, and the station called Summit is at the top. A change of 1.4 miles long has been made here. By this is effected a saving of 100° in curvature and 18 ft. in grade climb. The maximum grade is reduced from 0.8% to 0.2% and the curves from 9° to 2°.

PENDLETON CHANGE.—This change is being made at Pendleton, 231 miles from Portland. It is 3,000 ft. long, and it saves 930 ft. distance and 103° in curvature. There is a new bridge of two 150-ft. spans across the Umatilla River.

SANDY RIVER BRIDGE.—This improvement consists of a new bridge only, it being located at the Sandy River crossing at Troutdale. The bridge has three 150-ft. through riveted spans and one 60-ft. deck plate-girder.

JOHN DAY RIVER BRIDGE.—This change consists of a new bridge across the John Day River 118 miles east of Portland. It consists of one 300-ft. through pin-connected span and one 100-ft. deck plate-girder span. The bridge replaces one with a single span of 400 ft., considered too light for present traffic.

LINE CHANGES PROPOSED.

DALLES TO COYOTE.—In this section of 82 miles there are 35 changes proposed, covering a total length of 38.3 miles. There will be a reduction in curvature of 1,743° and the elimination of 101.7 ft. in adverse grades, also a saving in distance of 2,388 ft. Among the changes is one between Dalles and Celilo, where about 1¼ miles of 1.25% grade will be eliminated.

It may be here stated that for the entire line along the Columbia, reaching to Umatilla (187 miles from Portland) the standard set for improvements is a 4° maximum curve and 0.5% maximum grade, with no adverse grades for westbound traffic. This portion is a water grade route, but local features of topography were the cause of occasional stretches of grade as steep as 1.0% or more in the old line. These are being eliminated as fast as practicable. The Dalles-Coyote changes will probably be started during 1907 if labor conditions are favorable.

YOAKUM-BARNHART CHANGE.—This proposed change is just beyond Yoakum, which is 215 miles from Portland and 28 miles southeast of Umatilla—where the road leaves the Columbia River. In this section the line runs in a narrow valley along the Umatilla River. The existence of one or two loop-bends in the river causes an excessive amount (for a plains country) of curvature in the present line, including one complete horseshoe curve.

The proposed change will be about three miles long; it will reduce distance by 6,300 ft. and curvature by 720°, and the maximum grade will be reduced from 1% uncompensated to 0.6% compensated. The new line will require a tunnel 920 ft. long. It will also require three crossings of the Umatilla River, but one being used on the present line, and each bridge will consist of two 150-ft. spans. This change has not yet been authorized.

A 55,000-BARREL TANK FOR STORING LOCOMOTIVE FUEL OIL AT ST. JOHNS, OREGON.

EXTENSIONS AND BRANCHES BUILDING OR PROJECTED.

ST. JOHNS EXTENSION.—This extension may also be considered a line change, in that it will afford an alternate line for traffic on the main line. From East Portland the O. R. & N. Co. has a spur running northwesterly down the right bank of the Willamette to St. Johns, a small manufacturing city about four miles above the junction of the Willamette with the Columbia. In this locality the two rivers are separated by a narrow neck of land called the "Peninsula." The top of this is a nearly level plateau having an elevation of 80 to 140 ft. above the rivers.

The present main railway line runs almost east, leaving the Willamette drainage by ascending Sullivan Gulch in East Portland—a distance of about 7 miles to the divide. This ascent has grades as steep as 1% uncompensated for curvature, which is objectionable for the movement of heavy trains. To avoid the climb over the divide it is proposed to run down the Willamette, passing through St. Johns and on around the point of the Peninsula and thence up the south bank of the Columbia to a junction with the present main line at Troutdale. By this route a water-grade is secured for the entire distance to Troutdale, though the distance is about 9 miles greater.

This project is at present being carried out by extending the branch already built to St. Johns on around the Peninsula. The extension is 20.3 miles long, and by it the maximum grade is reduced to 0.2% and the curvature from about 8° to 2° 30'. When the extension is finished all heavy freight trains will go over it in place of the present line. It will also be largely an industrial line on account of very large manufacturing establishments that are locating on the bottom lands of the Columbia and Willamette around the Peninsula.

A radical improvement is projected for the future in connection with the extension. The Oregon & Washington R. R. Co.'s proposed line (controlled by the same interests) which is to run from Portland to the Puget Sound, will leave Portland by way of East Portland and will cross the Columbia at Vancouver on the bridge being built by the Portland & Seattle Railway. The St. Johns branch to near the south end of the bridge will be used by this road, but it is proposed to make a radical change by tunneling through the Peninsula, thus avoiding the long detour around the point of it. The proposed tunnel line will leave the Willamette nearly two miles above St. Johns and will run north, straight through the Peninsula. The length of the tunnel will be 5,425 ft. The tunnel will have to be lined throughout. The greatest depth of ground over its crown will be about 90 ft.

Where the line beyond the tunnel crosses the extension up the Columbia a four "Y" connection will be put in. By this trains can be routed in any direction, sent through the tunnel, or around the point of the Peninsula, and trains between Puget Sound and the East can be diverted here without having to go through Portland.

WILLSBURG-BEAVERTON CUT-OFF.—This is an improvement to be made on the Southern Pacific Co.'s lines in Oregon, and as these lines are under the same local and general management as those of the O. R. & N. Co., it will be here described. The Southern Pacific Co. has three lines running out of Portland, there being the East Side Division (main line running to California), the Yamhill Division (a branch running southwesterly) and the West Side Division (a branch running westerly). Of these, the first and last named reach the Union Depot in Portland; the Yamhill line reaches a separate depot at the foot of Jefferson St., on the west bank of the Willamette. There is no direct rail connection between the latter depot and the Union Depot and yards, so that to transfer cars from one to the other requires a transit over the Yamhill Division to a junction with the West Side Division at St. Joseph and thence back to Portland over the West Side Division, or vice-versa. A carriage of 83.6 miles is thus required, although the direct distance between the depots is less than 1½ miles.

Another decided objection to the present situation is the fact that for some distance in Portland the West Side Division runs through the heart of the city, on Fourth St. There is a very heavy grade on a portion of this street, requiring the use of helpers even on short trains. The two causes combined have impelled the Southern Pacific Co. to plan a radical change.

It is proposed to build a cut-off from Willsburg, on the East Side Division and at the south city limits of Portland, across the Willamette River to a connection with the Yamhill Division, and thence westerly and northerly to Beaverton, a station on the West Side Division about eight miles west of South Portland. The cut-off line will be about twelve miles long. Of this 10.2 miles will be entirely new line, and the remainder will be portions of the Yamhill line, the route of which for four or five miles is followed by the cut-off.

The maximum grade on the new line will be 0.5%, and the sharpest curve will be 4°, excepting a 10° curve at the Oswego bridge approach. A most noteworthy feature will be the crossing

of the Willamette at Oswego, a station on the west side of the river and about seven miles upstream from the center of Portland. The bridge will consist of two 300-ft. steel, pin connected, through spans, with a clearance of 75 ft. above the average low water in the river and of 53 ft. above average high water. All existing bridges across the Willamette are necessarily provided with draw spans.

The depth of water at the center pier at lowest low water is 60 ft. The height of center pier above the stream bed will be about 136 ft., and it will contain 4,400 cu. yds. of concrete. As the spans are 52 ft. high in the middle, they will have a total height of 127 ft. above low water. Each span will weigh 525 tons. Work will be prosecuted as fast as possible during 1907.

With this line completed the rail distance between the two depots will be reduced to about 15 miles, traffic from the Yamhill division south of the connection can be diverted over the East Side line and taken to the main freight yards, and the use of Fourth St. in Portland for the West Side Division will no longer be necessary. The section of the latter reaching to Beaverton, a distance of 11 miles, will be abandoned as a steam road, but it will probably be converted into an electric suburban road. The section of the Yamhill Division between the Jefferson St. Depot and Oswego—7 miles long—will be operated only as an industrial track.

ILWACO RAILWAY & NAVIGATION CO.—This isolated branch of the O. R. & N. Co. is located on the Pacific coast, on the Washington side of the mouth of the Columbia River. An extension is being made from Ilwaco up the north bank of the Columbia River to Cooks Station, a distance of 13.9 miles. The extension has 0.4% maximum grades and 8° maximum curves.

UMATILLA CENTRAL R. R.—This branch is being built from Pendleton, on the main line, southerly to Pilot Rock, a distance of 14½ miles. It has 1% maximum grades and 8° maximum curves.

ELGIN TO JOSEPH EXTENSION.—This is an extension of the branch at present operated from La Grande to Elgin, 21 miles long. La Grande is on the main line, 305 miles east of Portland. The extension reaches from Elgin to Joseph, a distance of 63.3 miles. The line follows northerly down the Grande Ronde River to its junction with the Wallowa River, and thence southeasterly up the latter to Joseph, a town near the north end of Wallowa Lake. Several towns are touched on the way. This road has maximum grades of 1.5% and maximum curves of 10°. It is about one-half completed.

OREGON, WASHINGTON & IDAHO R. R.—This connecting branch runs from Riparia, Wash., on the O. R. & N. line between Umatilla and Spokane, up the right bank of the Snake River to Lewiston, the latter being just over the line in Idaho. This road is being built jointly by the O. R. & N. Co. and the Northern Pacific R. R. Co. The distance is 72.3 miles. A bridge will be built across the Clearwater River at Lewiston. The bridge will have five 150-ft. spans and one 240-ft. drawspan.

This road is of first class standard construction, as it is an important main line connection. The maximum grade is 0.2%, with no adverse grades, and the maximum curve is 2°. The road is about 90% completed.

LIMITS OF GRADES AND CURVES, STANDARDS OF CONSTRUCTION, ETC.—Between Portland and Huntington the O. R. & N. Co., main line has three summits to overcome. The first and highest of these is the crossing of the Blue Mountains, the summit being at Kamela, at an elevation of 4,205. The maximum grade on each side is 2%. The second summit is the Telocaset divide, between La Grande and Baker City, the elevation being 3,448. The maximum grade on the west side is 1.5%, it being 1.0% on the east. The third summit is the Encina divide, shortly east of Baker City, the elevation being 3,964. This has a maximum grade of 1.5% on each side.

The sharpest curve used on the O. R & N. Co. main line is 10°. There are but few curves of this degree, the maximum for the most part being 8°. In all the line changes 4° has been used as the maximum.

On the sections of road extending over the three summits the controlling grades and curves are necessarily quite different from those on the remainder of the line, and the grades and curves, particularly the former, cannot be very radically reduced.

In passing over the Kamela divide a number of crossings are made of the creeks coming down either slope. To reduce these a method of channel change of the creek itself has been adopted, in which certain projecting rock ridges are tunneled through to provide passage for the stream, thus allowing filling up of the bridge crossings—two to each tunnel.

In all new bridge work the railroad company is preparing for the future in assuming heavier rolling stock than any it yet has. The assumed load consists of two consolidation locomotives, each with the following weights: On drivers, 220,000 lbs.; on trucks, 25,000 lbs.; tender, 140,000 lbs; total, 385,000 lbs. This is followed by a uniform load of 5,000 lbs. per lin. ft.

In all of its recent bridge work the O. R. & N. Co. has erected the superstructure with its own forces, contracting only the substructure. On the Southern Pacific lines both the steel work and the substructure are done by the railroad's own organization.

CHANGES IN MOTIVE POWER.—The O. R. & N. Co. has been rapidly changing its locomotive fuel from coal to oil. There are at the present time on the O. R. & N. Co.'s lines and the S. P. Co.'s lines in Oregon, 13 storage tanks and 11 gravity tanks—the latter for filling the locomotive tenders directly. Of the storage tanks there are seven of 5,000 bbls. capacity, one of 15,000, four of 30,000, and one of 55,000 bbls. capacity. The last named is located at St. Johns, part way up the hillside from the track, and is filled by pumping from vessels in the river. The oil is brought from Southern California by water. This tank is 115 ft. diameter by 30 ft. high. The service or gravity tanks each have a capacity of 28,500 gals.

CAR WHEELS FOR COMBINED INTERURBAN AND CITY SERVICE.*

By C. SKINNER.†

I have interpreted this subject to refer to wheels for heavy interurban cars, operated over both interurban and city tracks, and in the treatment of the matter I have in mind only the operation of high-speed cars weighing 40 tons or more. I am fully satisfied that in the selection of wheels for this class of service the specifications of the Master Car Builders' Association should be adhered to as nearly as possible. It may be, and in our case was, necessary to reduce the size of the wheel flanges somewhat in order to operate over city streets, and I believe the flange dimensions may be safely reduced to 1⅛-in. or 1 in. in depth and to 1¼-in. or 1⅛-in. through the throat, but I am firmly of the opinion that the 4-in. tread is essential for safety and to obtain proper efficiency in braking with heavy equipment.

Since the introduction of the rolled steel wheel is comparatively recent, I will not enter into a discussion of the relative merits of this type as compared with the steel tired wheels which we have in use on all of our motor equipment.

My experience has been that the flangeless brakeshoe is best for service in which heavy cars are operated over grooved rails in city streets, for the reason that the flange wear, already excessive, should not be increased by the use of a flanged shoe. We have demonstrated by practical tests that the wear on the wheel flange by a brakeshoe adhering to the flange of the wheel reduces the possible length of time between tire turnings by nearly 30%. Therefore, in the operation of heavy equipment at high speed, with flangeless brake shoes, we need a fairly wide tread to obtain sufficient braking power.

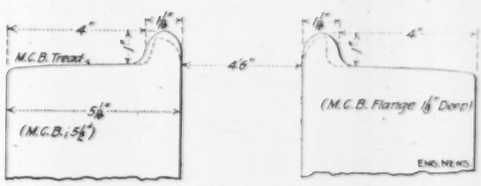
The question of safety in tracking is extremely important. No system of inspection, no matter how thorough, can be depended upon to detect a wheel loose and working at the axle fit, at just the time it occurs. Therefore, why reduce the factor of safety from this not unusual trouble, especially when we have to meet a condition in operating over city tracks that greatly increases the liability of wheels to loosen on the axle fit. Recognizing the desirability and expediency of interurban companies operating their cars over the tracks of city companies within the limits of municipalities, I believe that in the operation of this same heavy equipment at high speed outside of city limits, safety must be the first consideration.

The following is a brief review of the experience of the Scioto Valley Traction Co. with the wheel question. This company commenced operation in July, 1904, and until about Dec. 1, 1904, it operated on its own tee-rail tracks exclusively, not entering Columbus over the city tracks until the latter date. The records from which figures were obtained for this report cover ten 60-ft. passenger cars of this company; these weigh 42 tons each, and are equipped with 36-in. steel tired wheels, having the M. C. B. tread, with flange 1 in. deep and 1 1/16 ins. thick through the throat. This was found to be the maximum size of flange which could be operated over the grooved rail tracks in the city of Columbus.

The accompanying drawing shows the exact wear on flanges of a pair of wheels removed from one of the cars on March 22, 1907; this pair of wheels had been placed under the car on Nov. 8, 1906, with tires newly turned to the dimensions mentioned above. The mileage made by this pair of wheels during this interval was 28,000 miles. This wear, however, was somewhat abnormal, as we average about eight months between turnings, or about 48,000 miles.

The first five months of our operation was over tee-rail track, as already noted, and I would call particular attention to the fact that during that time our wheel flanges showed no perceptible wear. Since Dec. 1, 1904, or during a period of about 27 months, we have been obliged to remove and turn 93 pairs of wheels for no other cause than worn flanges. The distance covered in going in and out of the city of Columbus is seven miles, about half of which is grooved rail with 1¼-in. groove.

The drawing shows the excessive wear on the inside of the flange. This wear, coming at the angle it does, shows a very severe wedging tendency, which finds its weakest point at the wheel and axle fit. The inertia from the swaying of the heavy car and climbing the inside of groove where track is out of alinement, makes it



Sections of Wheels of Interurban Electric Cars, Showing Flange Wear Due to Running on Grooved Rails in Streets at Columbus, O.; Scioto Valley Traction Co.

very difficult to maintain an immovable wheel at this fit. In less than two months after commencing operation over the city tracks, we had a large number of loose wheels; that is to say, they had moved out of gage on the axles, notwithstanding that it afterwards took from 45 to 60 tons hydraulic pressure to move the same wheels in the shops. We replaced these wheels at from 90 to 125 tons pressure, and have been fairly successful in keeping them tight. Judging from our experience, I should say that wheels for this class of service should be pressed on at about 90 tons, with a minimum of 70 tons. I have handled wheels of the same design on steam railways for a number of years, using 40 tons as a maximum pressure, with no trouble from loosening.

Although over half of the wheels under the cars covered in this report have been refitted on account of becoming loose, we find it necessary to maintain the most rigid inspection of our wheels. We keep a trained inspector, whose principal duty it is to gage each pair of wheels each day a car is in the shops, which is every alternate day. The spread is measured by a solid immovable gage and a written record is made of the position of the wheels on the axle. This report is turned into my office, where it is carefully checked with the former records. It is not unusual even now to find a wheel loosened, notwithstanding the enormous pressure at which we put them on.

Some idea of the excessive wear of flanges due to the cause mentioned may be shown by comparison with the life of the same wheel under equipment of equal weight on steam railways, it being not unusual to obtain a mileage of steam roads of about 200,000 miles between turnings, while our average is 48,000 miles.

*Abstract of a paper read at the meeting of the Central Electric Railway Association at Dayton, O., March 28, 1907.

†Master Mechanic, Scioto Valley Traction Co., Columbus, O.

TAR AS A COLORING MATERIAL FOR MORTAR has recently been used by a brick mason. In erecting a number of brick houses he ran short of black mortar color and used as a substitute some tar which had been partially refined. After a lapse of several years it is claimed that the color is as strong as ever, showing a remarkable newness where the mortar made with usual color will need repairing and pointing up before long.

THE OAKLAND BRIDGE, PITTSBURG, PA.: A STEEL ARCH WITHOUT HINGES.

By WILLIS WHITED,* Assoc. M. Am. Soc. C. E.

Pittsburg is notable for the great variety of bridge structures in the city and vicinity. At present there is nearing completion in that city one of the few no-hinged long span steel arches in the United States. The method employed for adjusting the arch to give each member its proper initial strees is, so far as the author knows, new, and is not only correct, but has been found to be practical and economical.

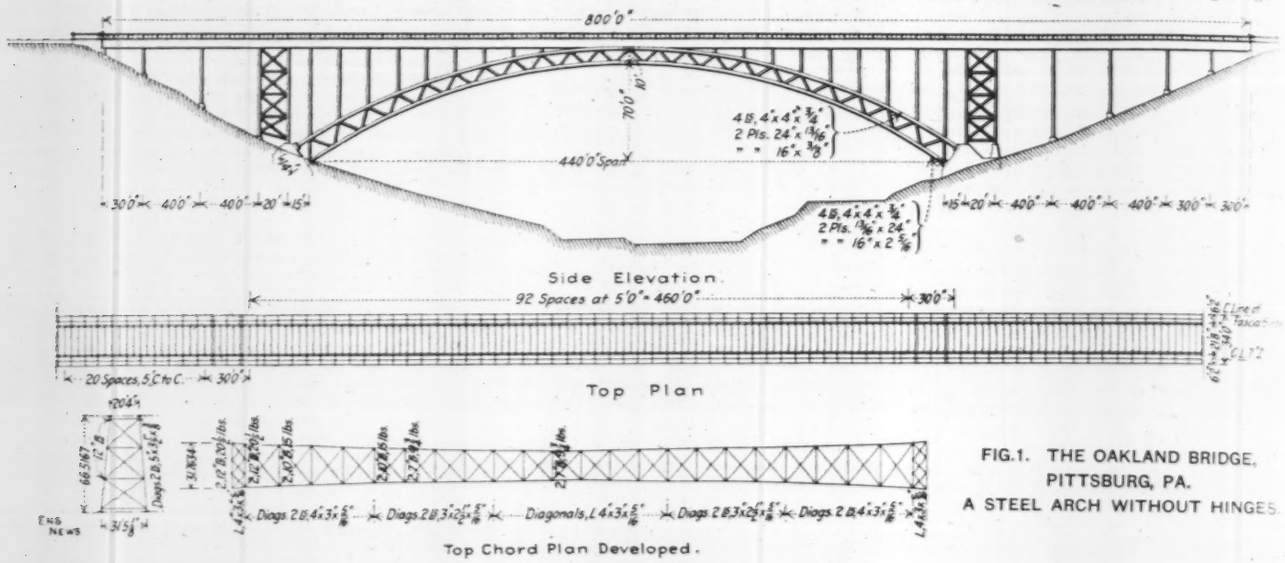


FIG. 1. THE OAKLAND BRIDGE, PITTSBURG, PA. A STEEL ARCH WITHOUT HINGES.

For many years a demand has existed for a bridge crossing the hollow that separates Oakland from Schenley Park. Plans and estimates were prepared by the author in 1901, under the direction of Mr. John Brunner, M. Am. Soc. C. E., then Superintendent, Bureau of Construction, Department of Public Works. These plans called for a two-hinged steel arch of 450 ft. span, with viaduct approaches, the total length of the steel work being 830 ft., with a roadway 20 ft. wide and two sidewalks, each 10 ft. wide and paved floor. The cost, about $160,000, seemed more than the city could afford. Finally, in 1904, $138,000 was appropriated, and, as it seemed impossible to spare any more in view of the many other improvements that were urgently needed, it was decided to go ahead and build the best bridge that seemed practicable for the money. The city accordingly advertised for bids on the original plans and at unit prices, on modified plans, which would come within the appropriation. At the contract prices it was found practicable to build the bridge within the appropriation by (1) reducing the width of the sidewalks to 7 ft. each; (2) making the abutments larger and shortening the steel work to 800 ft.; (3) shortening the arch to 440 ft. and making it no-hinged; (4) making all masonry below ground of concrete and reducing the sizes of the piers and abutments to correspond with the reduced width and weight of the bridge.

The accompanying drawings show clearly the construction of the viaduct, the approaches being of the same type as the part carried by the arches. It is the ordinary type of steel plate girder viaduct, consisting of two longitudinal plate girders carrying I-beam floor beams with a buckleplate floor and resting on columns which in the approaches fit upon concrete piers and in the arch proper upon the upper chord of a lattice girder arch rib, with 440 ft. span and 69.6 ft. rise. The 5-16 in. roadway buckleplates rest directly on the crossbeams, while the ¼-in. sidewalk buckleplates are carried by a 7-in., 9¾-lb. channel at the curb, a 7-in., 15-lb. I-beam at the center and a riveted fascia girder at the outside, all carried by the floor beams. The floor beams consisting of 7-in., 9¾-lb. channels, top and bottom, latticed together with 3 × 3 × 5/16-in. angles. The column bents are built of laced 12-in. channels with horizontal struts of two channels with webs vertical and X-braced with two angles. These bents have an outside batter of 1 in. to the foot. The chords of the arch ribs are built in a box-girder section with 4 × 4 × ¾-in. flange angles and 24 × ¾-in. webs, with 16-in. reinforcing plates of the required thickness outside. The diagonal members of the rib are all of two laced 15-in. channels except at the two end panels, where large sections were required. The two arch ribs are braced together with laced channels. Whenever angles or channels are used for bracing, the legs or flanges are turned down so that they cannot hold water or dirt.

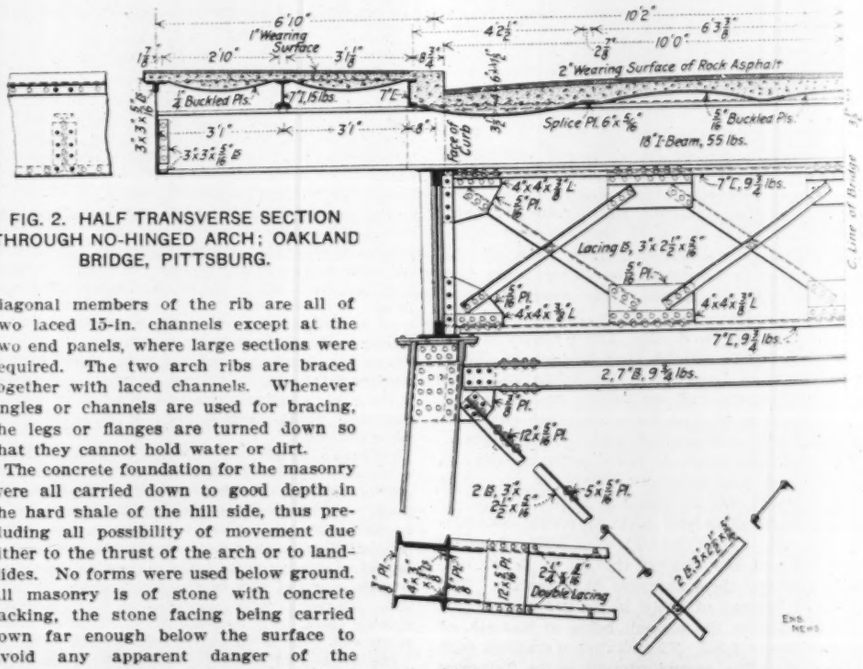


FIG. 2. HALF TRANSVERSE SECTION THROUGH NO-HINGED ARCH; OAKLAND BRIDGE, PITTSBURG.

The concrete foundation for the masonry were all carried down to good depth in the hard shale of the hill side, thus precluding all possibility of movement due either to the thrust of the arch or to landslides. No forms were used below ground. All masonry is of stone with concrete backing, the stone facing being carried down far enough below the surface to avoid any apparent danger of the concrete foundations being exposed by landslides.

The arch piers were made without stone facing on the skewbacks, but instead eight 20-in., 65-lb. I-beams, 18 ft. long, were put at each skewback and wedged up to their proper position and grouted. No bolts nor separators were used, neither were the tops of the beams planed, it not being considered practicable to adjust them with such accuracy; instead, the shoes were left well grouted underneath and filled with concrete, without bolts or separators, to large stones, as it is almost impossible to properly bed the latter in mortar. If planed sole plates rest directly on the grillage, the beams can be planed on top and leveled more accurately than a stone can be dressed, or the beams can be left rough and the shoes that rest thereon grouted. The concrete between the beams protects them against corrosion and serves the purpose of separators. If, however, the outside beams come close to the edge of the masonry on which they rest, bolts may be necessary, but the holes may be left large enough to permit adjustment of the beams for height, etc., the bolts being intended solely to prevent the beams from spreading. All the columns on the approaches were bedded by raising them up sufficiently to place a bed of thin mortar under them, and while it is still soft, letting them down into it. The weight on the columns

*Assistant Engineer, Department of Public Works, Pittsburg, Pa.

forced out the surplus grout and make a perfect bed. If columns are bedded in this way, it is not necessary to dress the tops of the piers very carefully.

The railing is somewhat elaborate but neat and substantial. As the bridge forms an entrance to the finest park in the city, the designer felt justified in spending considerable money for esthetic purposes.

The sidewalks are to be granolithic, that being considered the best for a bridge. Asphalt forms a very pleasant surface to walk on, but in a very few years it becomes worn in spots sufficiently to hold puddles of water, unless the bridge has considerable grade. The principal objection to asphalt, however, is that it shrinks somewhat, leaving cracks between it and any exposed steelwork which fill with dirt and water, causing rapid corrosion of the steelwork. Cement, on the contrary, adheres closely to the steel and protects it. Asphalt forms an almost ideal roadway paving on a bridge as long as it lasts and it is quite durable, as the action of the vehicle wheels tends to close up any cracks that may be formed between it and adjacent steelwork. When it is laid on buckleplates they should be thoroughly protected by a layer of concrete at least as rich as 1:2½:5; asphalt binder is too porous, affording very little protection to the steel. The tops of the buckleplates should be merely freed from loose rust and scale, no paint being applied. The concrete adheres more firmly to an unpainted surface.

The curbs are to be of plain concrete; the wear on the curbs is much less severe on a bridge than on a street, and metal protection is seldom necessary except, perhaps, on the curved curbs at the ends.

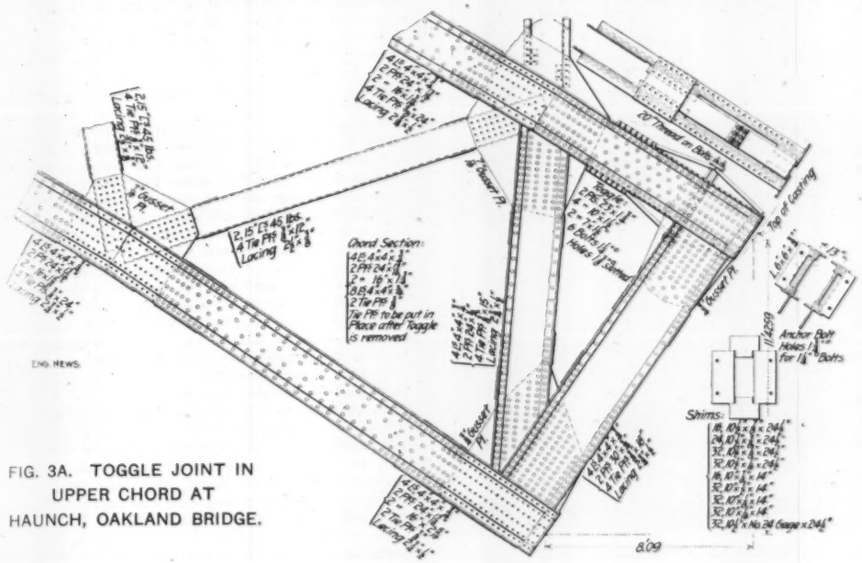


FIG. 3A. TOGGLE JOINT IN UPPER CHORD AT HAUNCH, OAKLAND BRIDGE.

The erection was accomplished by means of a traveler (Fig. 8) consisting of a pair of stiff-leg derricks braced together and mounted on wheels running on rails on the floor of the bridge. The hoisting engine was carried on a platform raised up high enough to permit the trucks delivering material to pass under it. One derrick boom was 75 ft. and the other 60 ft. long, and they were used for erecting both the falsework and the steelwork. The chords of the arch were shop riveted in double lengths to save field riveting. The riveting was all done by compressed air with a Hall Straight Line 14 × 14 × 15-in. compressor. It was used for riveting, reaming and bucking up. With an 80-HP. boiler it supplies air for nine gangs of riveters with a good margin.

The adjustment of the stresses in the redundant members of the arch was quite a simple process. The bottom chord at the crown of the arch was cut in the center, and, as shown on Fig. 3, was so designed that a powerful toggle could be applied to give it its initial stress by forcing open the joint in the center and inserting shims to hold it there. After the insertion of the shims the toggles were removed and the chord so finished that its appearance was not materially different from the others. The top chords at the springings (Fig. 7) were adjusted in a similar manner and shims inserted between the ends of the chords and the cast steel shoes to hold them.

The amount of stress applied with these toggles was determined by measuring the strain in the chord by means of a micrometer gage applied between two cast iron plugs bolted fast to the chord at points 33 ins. apart. A hole, "H" (see Fig. 5) was started in one side of each plug with a ½-in. drill, the holes facing each other in each pair of plugs. A pair of these plugs was bolted to the center line of the web, on each side of chords adjacent to the toggle joints at crown and haunch. As pressure was applied by the toggle the chord would naturally compress, the amount of compression being read by the micrometer between the two holes. The gage would accurately bottom in the holes "H," and successive gagings would seldom differ by more than .0003 in. Care had, of course, to be exercised in cleaning the holes before the gage was applied. Brass or nickel-plated plugs would have been somewhat better on account of the absence of rust. The plugs could have been spaced about 10 ft. apart to advantage. The changes in length due to load are so minute that great care must be exercised in every detail. The results, however, are very satisfactory.

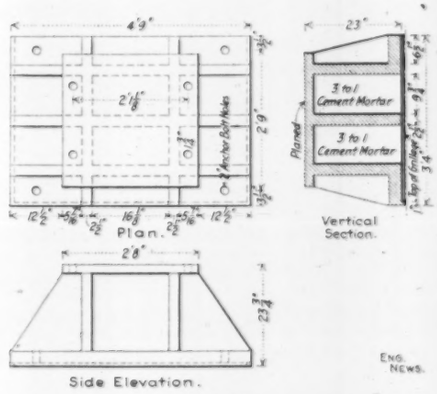


Fig. 4. Details of Cast Steel Shoe for No-Hinged Steel Arch of Oakland Bridge at Pittsburg.

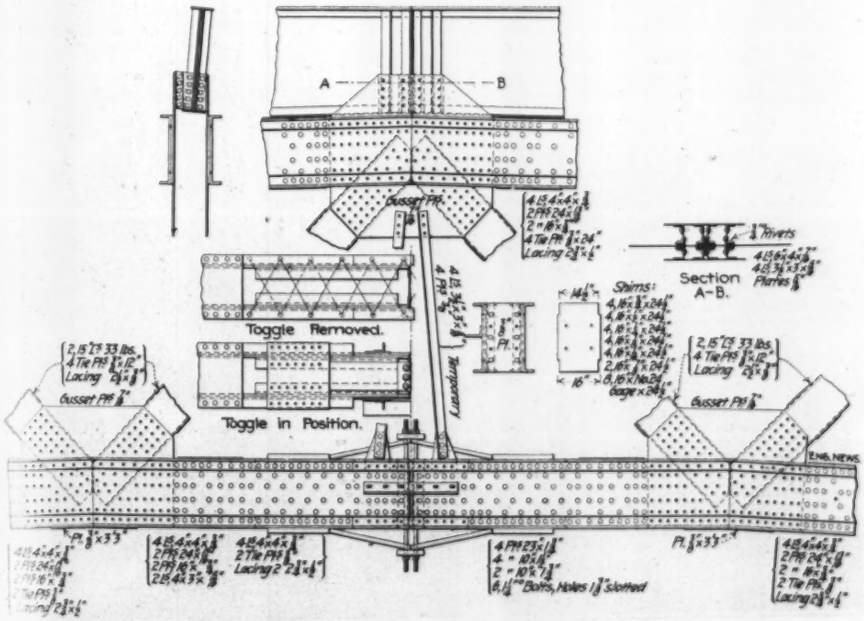


FIG. 3B. TOGGLE JOINTS AT LOWER CHORD AT CROWN, OAKLAND BRIDGE.

The arch was erected practically as a three-hinged arch, that is, the bottom chords at the crown and the top chords at the springing were left slack and after the span was swung, the toggles were tightened up till the strain in each chord was correct and the shims inserted to hold them. Care was taken, of course, to see that the splices were all closed up in the slack chords.

The stresses in the arch were calculated by assuming one end to be fixed, with a unit load at each panel point in turn and then determining the horizontal and vertical deflections at the other end, assuming it to be free. The horizontal and vertical deflections due to unit horizontal and vertical load at each end were then calculated. Four equations of conditions were thus formed, the conditions being that the deflections due to the end reactions should be equal and opposite to those due to the load. The solution of these equations gave the end reactions, from which were calculated the stresses in each member. With the stresses developed by a unit load at each panel point, the loading was so placed as to produce a maximum stress in each member. This is an extremely laborious method, but it is accurate, and great accuracy is required, because the stress in a member is generally equal to the difference between the stresses due to the panel load or loads and those due to the end reactions, and a comparatively slight error in any one of these makes a great difference in the stress. Graphic methods were tried but the re-

FIG. 6. ARCH PIERS FOR OAKLAND BRIDGE, PITTSBURG, PA., SHOWING IMBEDDED I-BEAMS FOR SKEWBACKS.

sults obtained differed so widely that they were abandoned.

The standard temperature was assumed to be 50° F. and the variations 40° F. either way. Although the temperature occasionally rises above 90° F., the combination of that degree of heat with a full load on the bridge would be so rare that the author felt justified in straining a point. The temperature often falls below 10° F., but in cold weather, the bridge being high and much exposed is practically deserted, so that a combination of extreme cold weather and a full load is scarcely to be feared.

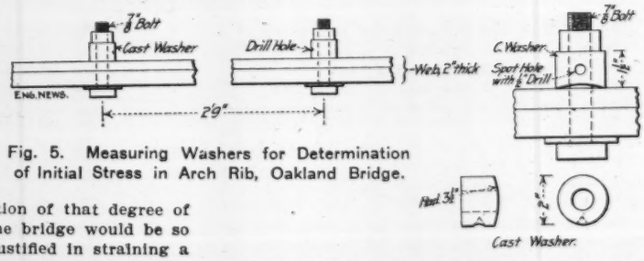


Fig. 5. Measuring Washers for Determination of Initial Stress in Arch Rib, Oakland Bridge.

The chords of the arch are arcs of circles, 10 ft. apart at the crown and 14 ft. at the spring. The parabolic form would perhaps have been somewhat more economical, but the circular form was adopted for esthetic reasons. The no-hinged arch is considered to be decidedly superior, from an esthetic standpoint, to any other type of bridge for a similar situation, and is enough cheaper than a two-hinged or three-hinged arch to amply repay the extra labor of making the calculations. It is, of course, not to be considered, unless the rigidity of the foundations for the arch piers is beyond question, but when they are held by the rock-ribbed hills of Western Pennsylvania, the engineer need have no fear on that score.

The bridge was designed by the author, and has been erected under his immediate supervision. The contractors for the substructure were the F. Felkel & Son Co., of Pittsburg, and the contractors for the superstructure are the Fort Pitt Bridge Works, of Pittsburg, who deserve much credit for the care and skill they have shown in doing the work. The contract for the paving has not been awarded. The mill and shop inspection of the steelwork was done by Hildreth & Co., of New York.

RAIL FRACTURES ON THE UNION PACIFIC system totalled 449 in the month of February, 1907, according to a statement made at a meeting of the board of directors of the company on May 9. Of this total, about 40% (179 fractures) consisted of breaks in 90-lb. rails which had been in the track only five or six months.

This statement is of especial interest in view of the records of rail breakages on railroads in New York State by the New York State Railroad Commission, reprinted in our issue of May 2, 1907, p. 494.

TRAIN RESISTANCE AND THE ECONOMICS OF RAILWAY LOCATION.*

Viewed from a modern standpoint, much of the railway construction in the early days of the development of the North American continent was of an inferior character. Great distances had to be traversed, the population of the country was sparse and scattered, and the grades and curvature were, therefore, too frequently determined by the amount of money to be expended per mile of road, rather than by a consideration of the probable traffic for future traffic and the economic value of grade and alinement features. Commercial progress of the country, however, followed the introduction of the railway and the financial problem of how to make a dollar earn the most began to receive greater consideration.

For a number of years past, the larger railway organizations have been spending large sums of money in improving the properties under their charge; but while there has already been an immense outlay in this respect, it may be said confidently that betterments in the future, both in new locations and in revision work, will be on a much greater scale than those of either the past or present. The general situation necessitating such changes may be said to be the outcome of circumstances. It is due in a great measure to a realization of the saving in operating expenses resulting from such betterments, to the increasing demand for cheaper rates and better service, the competition of railways with one another, and, more especially, to the construction of new lines designed on better economic principles.

In the effort to reduce train mileage, locomotives and rolling stock generally have been greatly increased in size, weight and capacity; and the effect of such changes has been: Bridge structures of increased strength, heavier rails, securer joints, more and better ballast, wider roadbed, and, consequently, an improved railway.

Besides changes of this nature, however, it soon became recognized that many improvements might be made in the distance, grades and alinement of the earlier construction which would effect a reduction in train mileage, independent of the class of rolling stock used. The province of this committee is, therefore, to investigate certain economic principles, in order that, eventually, helpful suggestions may be made to railway engineers and railway managers engaged in the construction of new lines, as well as of grade and alinement revisions.

It is usually comparatively easy to estimate the cost of a projected railway or an improvement to an existing one. The actual cost, however, of operating such a line, or the value of the saving in operating expenses which

*Abstract of a report presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, held at Chicago in March. This committee is composed of the following members: W. McNab, Grand Trunk Ry.; W. D. Taylor, C. & A. Ry.; Prof. C. F. Allen, Mass. Inst. Tech.; J. B. Berry, Rock Island System; V. G. Bogue, Western Pacific Ry.; J. F. Burns, L. & N. Ry.; W. W. Colpitts, K. C., M. & O. Ry.; W. L. Darling, Northern Pacific Ry.; W. E. Dauchy; Lewis Kingman, Mex. Cen. Ry.; O. E. Selby, C., C., C. & St. L. Ry.; W. B. Storey, Jr., Santa Fe System; F. L. Stuart, Erie Ry., and W. L. Webb.

FIG. 7. TOGGLE JOINT AT SPRING OF NO-HINGED ARCH, OAKLAND BRIDGE, PITTSBURG, PA.

is considered possible by any proposed physical change in the road or in the method of operating its trains, due to a modification of alinement, distance, or grades, is more or less uncertain.

To the proper location or re-location of a railway can be decided intelligently, it is necessary that the factors governing its earning power be properly understood, and the relation between the purely engineering and the financial features thoroughly grasped. Railways are built as commercial undertakings for profit, and a railway that can furnish the most economical transportation, as well as money being considered, will finally show the largest net earnings.

There are three principal factors which affect profits, viz., gross earnings, operating expenses and fixed charges, which are, in a great measure, dependent upon the location of the road with regard to the sources of traffic. With a given amount of traffic and proper location and construction, the greater the first expenditure (with its consequent improved road) the less will be the operating expenses, but the greater the fixed charges. Increasing one decreases the other. With a given volume of traffic the economic location is the one in which the sum of fixed charges and operating expenses is the least; and a more economical location is obtained when interest and renewal charges on additional expenditure for construction are saved in decreased operating expenses, or when increased operating expenses are saved in reduced interest and renewal charges on cost of construction. The most economical location is secured when every gain possible has been effected, both by decreased cost in the one case and decreased operating expenses in the other. In grade reduction, it is the saving in number of trains, even if each train costs somewhat more.

The effect of differences in location on such factors must be understood before a proper and economic location can be determined. If it can be computed that by certain physical alterations in alinement or grades, or by any change in the method of operating trains, the expense of each train over a proposed line or the number of trains to handle a given traffic can be reduced, then the only problem remaining is the financial study of the relative values of the proposed expenditure and the expected annual saving.

It is often stated that any really meritorious proposition can command the requisite capital, provided that it is properly exploited. Although there is considerable truth in this statement, it is also true that there is a wide difference in the amount of effort necessary to raise money, depending on the status of the corporation making the effort. It is perhaps unfortunate that the financial standing of many railway corporations is so unlimited, that many changes, which probably could not be justified by any rational method of computation, are recklessly made after slight consideration. There may be little or no reduction in operation expenses and certainly not enough to justify the capital expenditure, but the financial strength of the company is so great that there is no reduction in dividends. There may be an actual increase in dividends, which only means that the financial strength of the road is so great, and is growing so rapidly, that the comparatively insignificant loss, due to fixed charges on an unjustifiable expenditure, is utterly swallowed up. On the other hand, the road which is financially weak must show unquestionable justification for any proposed improvement, and even then the financial reputation may be so limited that a really meritorious project may fail for lack of funds.

There can be no question regarding the justification of providing for traffic that may reasonably be expected for a considerable period after the plans are made. There will be an interval of a year or more after the plans are made before the road is built. Several years more may elapse before the normal traffic is obtained. If the increased traffic cannot be economically handled with the facilities provided, then the railway is confronted with the choice between an uneconomical handling of traffic or an immediate additional expenditure with its accompanying loss and waste of work already done.

Of course, much depends upon the character of the

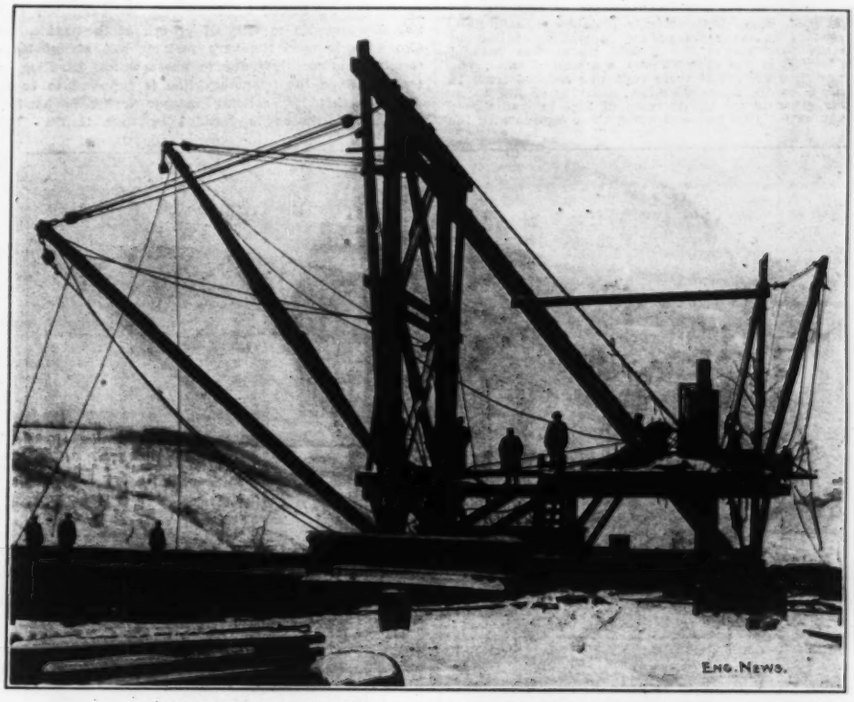


FIG. 8. TRAVELER USED IN ERECTION OF OAKLAND BRIDGE.

change and the amount of the waste. In territory where the topographical features are extreme and the financial aspect a governing element, cases may arise in new construction in which it is necessary to temporize with the profile in regard to limiting grade; that is, to construct a temporary line with grade steeper than the limiting one, a line which will be used until future traffic conditions warrant the construction on the alinement as projected. In such cases, in the consideration of the economic value of reducing the grade, it must be taken into account that the cost of any temporary work thrown away must eventually be borne by the permanent line. This fact should emphasize the desirability of avoiding temporary work whenever the finances of the company warrant the immediate construction of the permanent line.

It is conceivable that a considerable improvement may be made by merely raising a fill in a sag without altering the horizontal alinement. The additional work in this case will cost but little more than it would have cost originally, with the advantage of saving several years' interest on the added cost. In the other extreme it might be necessary to utterly abandon a considerable section of the line, and in such case the road would become perpetually burdened with an interest charge on both lines. The very patent fact that improvements, especially when not planned during the original construction of the road, so frequently require the abandonment of considerable old work, the cost of which will be perpetually represented in the fixed charges, causes a delay in the reconstruction for a number of years until the disadvantages of uneconomical operation become so great as to be intolerable.

The possibility of permanently utilizing the temporary line as a branch line, or even as a mere freight track by which to reach factories and other industries, may exclude all permanent loss from the question. It may happen that the line can be used to handle the local traffic, and one more direct for through business built later; the temporary line could then be used as a second track if the gradients are favorable in one direction. The cheap temporary line serves its original purpose and saves the immediate construction of the expensive permanent line, and yet both the preliminary and the later expenditure are fully justified by their utilization.

As a practical result, it may be taken for granted that a much heavier traffic is needed to justify the abandonment of a temporary line than would justify the construction of a permanent line designed for heavy traffic. A very interesting collection of figures has recently been brought to the notice of the committee. The name of the road and the exact location of the improvement need not be stated, but the essential facts and figures are given.

A section of the road over 83 miles long was built originally with very sharp curvature and heavy grades in order to reach certain coal fields. It was considered imperative to reach the coal fields at once, and therefore the construction of an alternative shorter low-grade line was deferred. About two years ago, the low-grade line was completed, at a cost of nearly $5,000,000 for 59 miles of road. Over 24 miles of distance is saved by the new line. The limiting grade against eastbound traffic has been reduced from 0.91% to 0.05%. The limiting westbound grade on the old line is 1.15%. On the new line, with the exception of a 0.24% grade on the approach to a bridge, there is no grade against westbound traffic. The total rise against eastbound traffic was reduced from 687 ft. to 69 ft., and against westbound traffic from 438 ft. to 17 ft. The maximum rate of curvature was reduced from 12° to 6° and the total curvature from 19,783° to 5,075°. The average degree of the curve was reduced from 7° 50′ to 3° 19′. This required 10,222 ft. of tunnels as against 4,096 ft. on the old line. In this case, however, the old line was not abandoned. It is still used for trains of eastbound empty coal and coke cars. But all the westbound business and also the eastbound time freight passes over the new line. The two lines may virtually be considered as a double-track line.

The results of this improvement are given by a comparison of the business of the year 1904, handled entirely on the old line, and that of 1905, handled on both lines as described above. Nothwithstanding an actual growth in business of 22%, the work was done with a saving of 2% in freight engine mileage, besides the disuse of three pusher engines, with a mileage of 138,816 miles in

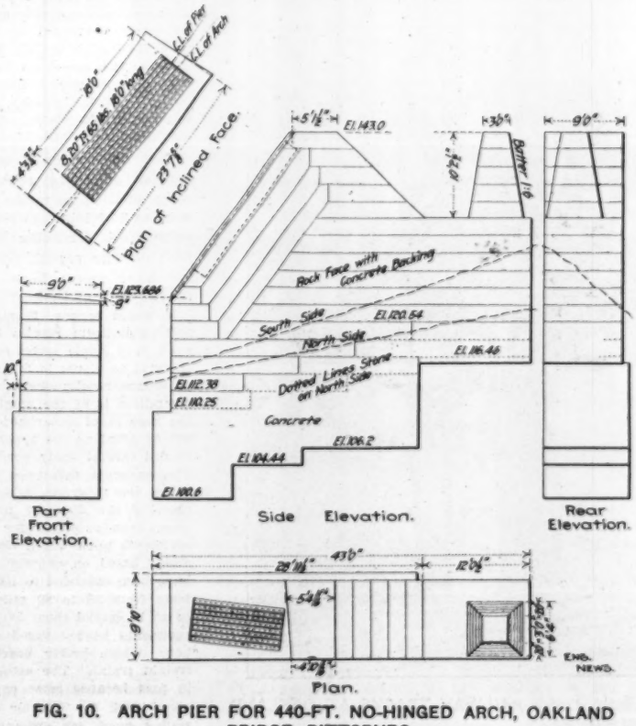


FIG. 10. ARCH PIER FOR 440-FT. NO-HINGED ARCH, OAKLAND BRIDGE, PITTSBURG.

1904. Again, in spite of 22% increase of business, the freight train wages were actually 19% less than in 1904. On account of the relief of the congestion of the old line, the overtime of the freight trains was reduced from $80,000 to less than $43,000, a saving of 46% . The average time of freight train runs was reduced from 18 hrs. 28 mins. to 12 hrs. 35 mins., a saving of 32%.

After allowing for the increase of 22% in traffic over the figures for 1904 and comparing these figures with the actual figures for 1905, it was estimated that the saving in operating expenses resulting from the construction and operation of the new line amounted to nearly $238,000, which is nearly 5% of the total cost of the new line. It is also claimed that the $238,000 does not fully measure the true saving owing to the fact that the old line was already being worked to nearly the limit of its capacity. But even accepting that figure as correct, a saving of 5% during the first year after construction may be considered a remarkable justification of the construction of the new line.

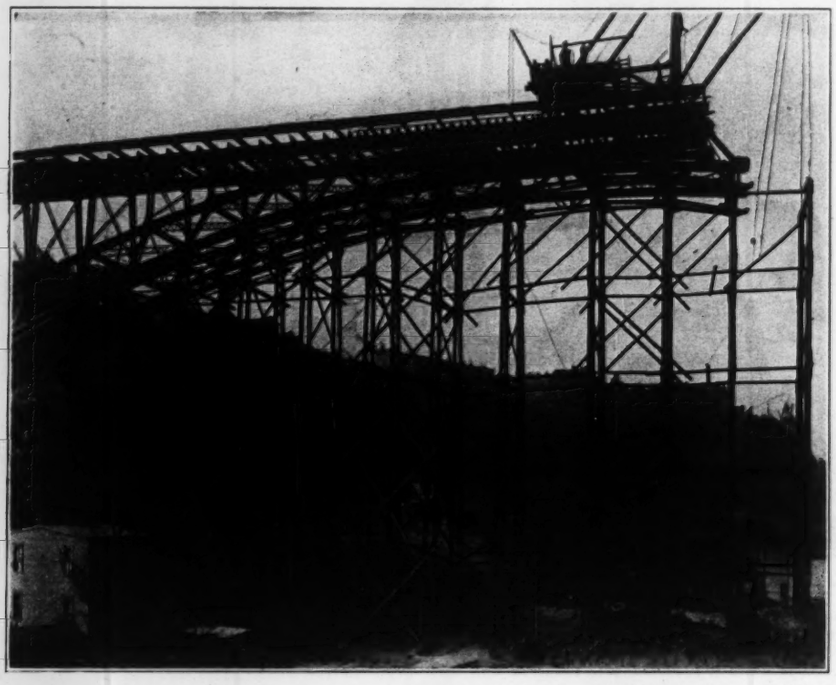


FIG. 11. NO-HINGED ARCH AT PITTSBURG, PA., IN COURSE OF CONSTRUCTION. SPAN, 440 FT.; RISE, 69.6 FT.

In regard to the period for which future traffic should be discounted, by the very nature of the case it varies with the character of the temporary line, the capital which will be wasted in abandoning the temporary line and the probable rapidity of growth of the traffic. It also depends upon the very variable and almost indeterminate annual loss due to uneconomical handling of traffic. Even the temporary line is supposed to be so designed that the existing meager traffic is handled as economically as is justified by such traffic. The growth in traffic is literally a growth, and does not increase by leaps and bounds. The justification of the larger expenditure changes from zero at the beginning of the period to some larger amount at which a change is imperatively demanded. Even the change, although gradual, is not necessarily at a uniform rate. There can be no empirical rule for determining the number of years in advance that it is desirable to provide for, but if the actual tonnage for a considerable period of years is plotted to form a curve, the extension of the curve will give probably the best obtainable prophecy of future traffic. Where changes can be cheaply made afterwards a small number of years seems proper, but where alterations suitable for increased traffic would mean the entire disuse of much expensive work, a much longer period in advance is advisable.

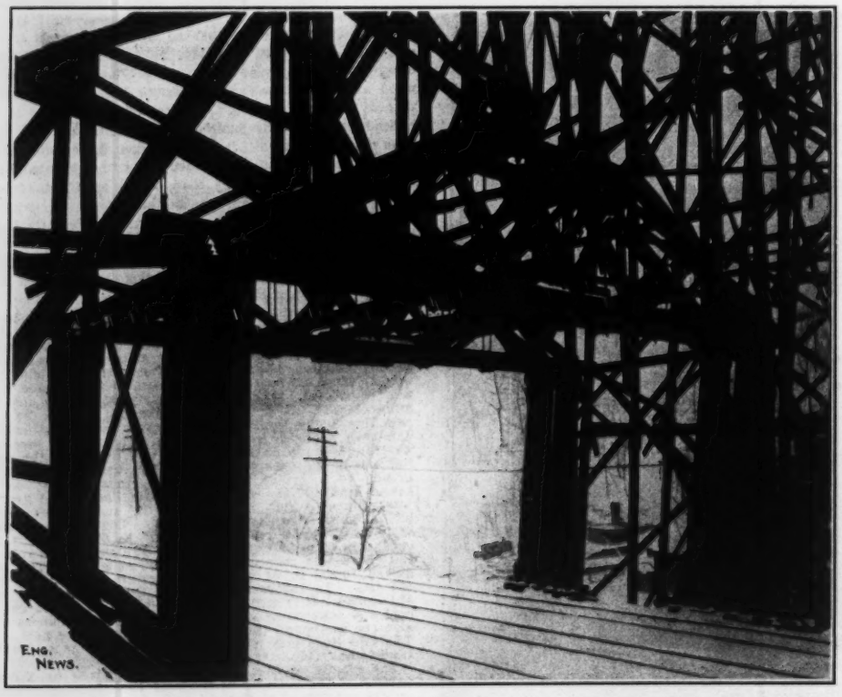


FIG. 9. HEAVY TIMBER TRUSS CARRYING CENTERING OVER RAILWAY TRACKS AT OAKLAND BRIDGE, PITTSBURG, PA.

A consideration of the foregoing uncertainties will show that a definite mathematical solution is seldom possible. It would appear as if the question must be finally determined by "judgment," although this judgment should be guided by a careful consideration of all the modifying elements, and each change should be considered by itself even on the same road.

The committee finds that at almost every step in the study of the economics of railway location, whether it be in connection with rise and fall, distance, curvature, or the adjustment of grades in any of its phases, the element of train resistance is very near the basis from which the investigation must be pursued. In connection with the comparison of the various formulas for train resistance, much attention must be given to a consideration of the elements or factors or influences which affect this resistance, and of the views about it which have been entertained by those who have given special attention to this subject.

It is hoped that many new experiments will be made under favorable auspices upon track substantially standard, in such a way that results found even in different places may justify comparison. The committee, however, feels that conditions in different parts of the country are still so unlike that it is desirable that each railway company should do some work upon such matters, under the local conditions that there prevail.

TRAIN RESISTANCE.

Train resistance may most conveniently be considered as made up of three parts: 1, Resistance on a level tangent; 2, Resistance due to grade; 3, Resistance due to curves. The resistance on a level tangent has been the subject of numerous experiments, the results from which have failed however, to present the degree of uniformity desirable. The resistance due to grade is capable of exact mathematical determination. The resistance due to curves may be said to have been determined by experience rather than by experiment, without perfect accuracy, yet sufficiently well to meet the general requirements of the case.

The resistance due to grade is a matter mainly of mathematical determination and is found by the formula $R = 20g$, where R = resistance due to grade and g = grade in feet rise per 100.

Curve resistance is estimated by different engineers at different values. The compilation once made by the Committee on Roadway of this Association showed that 0.8-lb. per ton per degree of central angle, or 0.04 for compensation per degree, well represented average practice.

Resistance on a level tangent is made up of various elements. These may be specified as follows: 1, Rolling friction (between wheel and rail); 2, Journal friction (between journal and bearing); 3, Atmospheric resistance (head, tail and side); 4, Oscillation and concussion. We know none too much about any one of these by itself, and it is perhaps not strange that our knowledge of their combined effect upon the train should be less satisfactory than is desirable. We know that journal friction decreases with speed up to a certain speed, and that atmospheric resistance increases with an increase of speed, possibly as the square of speed. Rolling friction we know still less about. About oscillation and concussion we know very little.

The committee presents a lengthy historical review of train resistance experiments, beginning with those made in 1818 by George Stephenson and Nicholas Wood. It also discusses 61 individual formulas for train resistance. This part of the report covers nearly 100 pages, and we have space here for only the following remarks in conclusion:

It would appear, therefore, that the difficulty of obtaining uniform results is so great, and the variation, even in a single series of experiments, is so great, that there is no virtue in trying to use undesirable expedients to secure results closer than one pound per ton. The committee is of the opinion that the actual variation in the results of experiments made on train resistance is not as great as the apparent difference, and that an extended careful study would reconcile many discrepancies. The apparent difference is very much exaggerated because the diagrams which have been made with lines showing the different formulas have, in almost every case, been extended far beyond the limits of the experiments upon which these formulas were based. Formulas based on experiments at 4 to 26 miles per hour have been extended to 100 miles. Formulas representing tests from 35 to 80 miles per hour have been plotted so as to extend them back to 0 miles. Few modern experiments have covered speeds from 5 to 30 miles per hour, which pretty nearly cover the limits for heavy freight trains. The actual differences have come about, in part because some experiments were taken long ago upon track far inferior to what exists now, and with rolling stock far different from what we have to-day,

and far less perfect, and, therefore, giving larger resistance.

The differences in many of the formulas can be explained also from the fact that the trains upon which the experiments were made were of very different weights; that, as we know, heavy and long trains give lower resistances; empty and short trains give much higher resistances. Most of the formulas for electrical trains show high resistances, probably because these trains are light and fast. Many of the formulas, evidently, if applied to trains of 500 tons weight, or larger, would fail to show the very high resistances per ton which were found for the light trains which were actually in use. In one way and another, it is believed that the discrepancy is far less than it appears to be, and perhaps no greater than we ought to expect it to be on account of the differences in condition, which are, in many cases, very evident. For instance, there seems to be no reason why we should take much account of the experiments upon short, light electric trains, when we are dealing with problems of heavy freight trains.

There is comparatively little direct information as to the laws governing the resistance of heavy trains. There are a few experiments showing the resistance at certain velocities, but comparatively few which tend to establish the shape which should be given to a formula for train resistance for such trains. It is not the purpose of your committee to suggest any formula at the present time. It is quite possible that further data following this report may bring in sufficient information, so that some formula can then be recommended. That we are not without some information of a valuable sort is to be seen by a reference to a paper by A. C. Dennis, Am. Soc. C. E., June, 1903:

During the past year more than 3,000 miles were run by the writer, with a dynamometer, on heavy freight trains loaded much beyond the rating for the ruling grade, to see what minor grades could be run with momentum, and where the stalling point was on those which could not be run.

The dynamometer record was condensed and plotted on profile paper above the grade and alinement; speed, pull, grade, and curvature being thus shown, so that the train resistance could be readily taken from the pull of the locomotive and compensated for change of speed, or velocity head, grade, and curvature.

The train resistance, in pounds per ton, compensated for change in velocity head, grade and curvature, was plotted for very many points and speeds for each train, and the mean of these points taken, as nearly as possible, for each train. The resistance under the conditions given differs radically from the results obtained by Wellington and other authorities experimenting with light trains, cars and rails.

The experiments indicate that the resistances which increase with speed balance very nearly the decreasing journal friction for trains of box cars of 2,000 tons or more, the tare of which is one-third of the gross weight on a solid frozen roadbed. The resistance for such a train is about 4.7 lbs. per ton for speeds from 7 to 35 miles per hour. Warm weather and a less rigid roadbed modify this, somewhat, reducing the resistances at low speed and increasing them at high speed, but the difference is so slight that the 4.7 lbs. has been used as a constant. The resistance due to cold varies from enough to skid the wheels, it is said, to practically nothing after the train has been run fast for some time.

The resistances after the train has stood for some time are about 2 lbs. per ton above the normal until the train has been run enough to get the journals well lubricated and warmed.

The resistances seem to be greater than normal when increasing the speed and less when decreasing, after compensating fully for the change of velocity head. A train increasing its speed from 10 to 20 miles per hour, and maintaining it, would pull appreciably harder than if just reduced to 20 miles an hour from a higher speed. From coasting tests, with the locomotive shut off, it appears that the resistances per ton for the locomotive were about the same as for empty cars, or about 9.0 lbs. per ton.

More recently, in fact after this report had been brought substantially into permanent form, a reply to this committee's inquiries, from A. K. Shurtleff, of the Rock Island System, contains further valuable information, part of which is in direct confirmation of Mr. Dennis' paper:

A number of dynamometer records covering over 3,000 train miles and over 2,500 miles of track on two different railway systems has shown many interesting things when studied in connection with the "log" book compiled at the time when records were taken. The records were made with the dynamometer car next to the locomotive and registering the drawbar pull. The scale weights of cars were taken. The different records covered trains averaging from 19 to 41 tons per car of train, and were taken on track varying from mud ballast with medium line and surface, to first-class track well ballasted with good line and surface. Districts covered varied from valley lines to mountain lines and grades. Temperature varied from zero weather to 60° F.

The tests show that no fixed rule can be deduced for train resistance that can be applied for all cases. Conditions of track as to line and surface affect resistance quite materially. Wind and the direction of the same with reference to direction of traffic also affects resistance, especially between the time of starting train and time of getting it moving at average velocity with the journals warmed up, and so long as time is a factor in moving freight, temperature must be taken into consideration. Resistance per ton will vary widely with the loading of the cars and condition of cars as to bearings, lubrication, etc. Therefore, only general rules can be laid down, and by experiment on each district these rules can be modified to suit conditions as they exist.

STARTING RESISTANCE.—The dynamometer records in a number of cases show that the "personal equation" of the engineman enters into the record as shown. In other words, he has attempted to start the cars with a jerk, thus throwing the recording pen up to a point showing resistance of over 25 lbs. per ton of train after deducting for grade resistance. The same train has at other points been started with about half of this resistance by a careful handling of the locomotive and taking advantage of all the slack possible. In starting trains with the least possible resistance, the whole mass is not started at once, but is set into motion by increments, hence a given number of tons in 40 cars can be started with less maximum drawbar pull than if loaded in 20 cars. Table I. gives a record of starting resistance on eight different trains, after correcting for grade:

TABLE I.—RESISTANCE AT STARTING.

No. Cars.	Avg. Tons per Car.	Temperature F.	No. Tests.	Lbs. Resistance per Ton. Max.	Min.	Average.
34	39.8	+30°	6	15.2	12.4	14.08
38	40.2	+20°- +44°	2	15.7	10.6	13.35
39	40.6	+33°	10	17.5	10.7	13.40
41	29.8	+25°	2	15.0	11.5	13.25
42	30.1	0 - +33°	6	16.4	11.8	14.35
43	38.7	+27°- +45°	2	14.3	13.6	13.95
44	28.9	+ 3°- +24°	5	18.2	12.6	15.52
45	27.3	+60°	2	17.8	13.0	15.40

There were some cases where a train had stood over night and 'froze' up, so that starting resistance was over 30 lbs. per ton. Temperature and the length of time a train stands still will affect starting materially. In some very few cases, where a stop was but for an instant, trains were started with 6 lbs. per ton draw bar pull above grade resistance. Above the freezing point it can be safely estimated that the average train can be started on level grade with 13 lbs. draw bar pull per ton of train.

RESISTANCE OF TRAINS IN MOTION.—The resistance of trains in motion drops after starting, so that at five miles velocity per hour it is practically at its minimum, although in cold weather it will be still higher than its normal until the journals are thoroughly warmed up. The dynamometer records show that draw bar pull does not increase with speed within the limits of ordinary freight speeds from 7 to 30 miles per hour. In one case where the conditions of track, grade, etc., were favorable, the record showed practically the same draw bar pull over long distances for a maintained speed of ten miles per hour, that it did where speed was maintained for considerable distances at 27, 31 and 35 miles per hour, respectively. The 35-mile test showed 0.08 lb. less resistance per ton, but this possibly was owing to slightly better track conditions.

Hence, without strong winds interfering, the draw bar pull per ton can be considered constant for a given train at any maintained speed after eliminating grade resistance. Engine resistance does increase with velocity. From the results obtained on track in good line and surface the following formula was deduced to cover train resistance back of the locomotive for temperatures above freezing and without strong winds.

$$\text{Resistance, lbs. per ton} = 1 + \frac{90}{\text{Ave. tons wt. per car.}}$$

The curve given by this formula can be plotted in diagram form, but Table II. gives the pounds per ton resistance for various loading of cars and also comparison with resistances as given by the Crawford and Daly curves, showing but slight variation from these, except in light loading:

TABLE II.—RESISTANCE WITH TRAIN IN MOTION.

Tons. per Car.	Pounds—Resistance per Ton. $R = 1 + \frac{90}{W}$	Crawford.	Daly.
15	7.00	6.10	6.1
20	5.50	5.04	5.2
25	4.60	....	...
30	4.00	3.82	4.0
35	3.57	....	...
40	3.25	3.14	3.1
45	3.00	....	...
50	2.80	2.73	2.6
55	2.64	....	...
60	2.50	2.45	2.3
65	2.38	....	...
70	2.29	2.27	2.2

In weather below the freezing point, the resistance will not vary much from these figures after the journals become warmed up to their work, but after starting trains, the resistance will be about two pounds per ton more until the journals become warmed and, in order to make scheduled time, at least this much allowance should be made, particularly where there is apt to be frosty rail morning and evening."

There is one point which has not yet been touched upon with relation to heavy freight trains. With very many cars in a train, it is reasonable to assume that the variations in resistance due to differences in quality of rolling stock, will be considerably neutralized, or the average on a large number of cars will be more nearly constant than the average on a small number, and since the effect of one or two especially heavy pulling cars will be less seriously felt in a long and heavy train than in a lighter one, the greater the number of cars the greater is the probability that the average will be more nearly the same; and it can be expected that future experiments on heavy freight trains will show somewhat greater uniformity in results than has been the case in most of the experiments which have been made, which have been, as has been stated, very largely experiments on passenger trains.

For the determination of questions of momentum grade, or of the sum justifiable to decrease the rate of grade, the load that can be hauled safely over the division forms the basis for computations, and this is determined by the upper limit of the experiments, rather than by the average, so that for questions of grade revision, and the use of momentum grades, the average line of resistance is too low. For equating for curvature and for determining the cost of curvature and the cost of rise and fall, average values seem appropriate to use.

The committee desires to call attention to the importance of accurate determination of speeds in making any experiments on train resistance, so that the increase of effort of the locomotive in increasing speed, or the decrease in effort in diminishing speed, shall be properly applied to the draw-bar pull in order to get the correct value of the train resistance upon a level tangent, or, as we may phrase it, the level tangent resistance. It is possible and probable that an attempt should be made to determine speeds with greater precision than has been done in most dynamometer cars.

In conclusion the committee makes the following recommendations:

1. Each company should conduct its own experiments for train resistance.
2. For the present for such experiments the dynamometer method should be used, and the resistance of train alone determined.
3. The determination of the amount of pull available at the drawbar at various speeds for locomotives of the different classes should be left to the proper motive power officials.
4. Speeds should be determined as closely as 0.1 mile per hour.
5. That for experiments on heavy freight trains at low speeds, the formula should have the shape $r = a + b V$.
6. That an additional term be added to show the effect of loading.
7. That all tests for train resistance should be made on tangents.
8. That for determining the sum allowable to save curvature, or to save rise and fall, the average line for train resistance should be used.
9. That for grade revision, for questions of momentum grade, a maximum line above the average train resistance should be used, a line somewhat near the outer edge of the experiments plotted in a diagram.

DISCUSSION.

Mr. H. G. Kelley (M. & St. L. Ry.)—On my road, on 46 miles of track on 1% grades and 5° curves, a certain type of engine, under the best of conditions, five years ago, would haul 950 tons. If there was a high head wind or poor rail the engine would fail to haul this tonnage. The grades on that district were changed from 1% to 0.6%, and the sharpest curves left in were 3°. The same engines with no greater expenditure of fuel today pull regularly, under all conditions except zero weather, 1,500 tons. In order to save material and costs momentum grades were used quite freely. In fact, two of the momentums were used up to the last theoretical foot limit, and the engines pulled the trains over the momentum grades without trouble day and night, so that personally I have no fear of using momentums where the conditions, physical or financial, make it advisable, although I am not an advocate of the free use of momentum grade.

Mr. Ewing (P. & R. Ry.)—On a part of our line we had 1% grades, and several of those were momentum grades. The tonnage rating, before the change was made, was 1,600. We reduced the grades to 0.5%, and the same engines are now pulling 2,200 or 2,300 tons.

Mr. D. D. Carothers (B. & O. Ry.)—I presume the committee has taken into consideration, in the matter of train resistance, the character of equipment, making careful memoranda, so that it will know the type of equipment that is being used. The cars and journals and wheels and rails are so different from those obtained when the formulas we use were deduced, that it would be very valuable to collect data from experiments brought up to date.

Mr. Kelley.—The problem confronting the committee is one not only of train resistance: it is the broad economic feature of location as it will affect the cost of operation and maintenance. It occurs to me that facts of this nature would assist the committee: In considering the effect and the operating value of curvature, on a 1% grade line on our road, single track, heavy engines, on curves of 3.5° to 5° in a period of 10 years the inside rail was worn out three times, and the outside rail was taken up in better condition at the end of 10 years than the last laying of the inside rail. That was rather soft rail. I personally considered the value of curvatures on maximum grade, single track, at an increased value for curves of sharper than 3°, taken from actual 10-year records. Now, the ordinary way is to place a certain value on curvature per degree. You are all familiar with Mr. Berry's admirable report, which gives a certain correction and certain operating values; and while I used practically the same value on maximum grades, single track, sharper than 3°, say, from 3.5° up, I add an additional arbitrary operating value because I know from experience that the rail wear and tie wear alone cause an additional fixed charge to the maintenance. The speed was 50 miles regularly down hill, and 7 miles up hill; elevation, up to 5.5 or 6 ins.; it was a freight and passenger traffic.

Mr. M. L. Byers (Mo. Pac.)—Some time ago we had up the question of reducing a 0.75% grade to 0.3%, and we were naturally required to make estimates to show what gain we could make from that reduction. We were fortunate in having at one point on our road a grade of 0.3%, possibly four miles in length. We thought we would get some cars on that grade and find out just what our engines could haul. My recollection is that with coal cars we started on the grade and we hauled at a speed of about 12 miles an hour, 2,350 tons gross. We changed the grades and put the line in operation with reduced grades, and started in with hauling 2,350 tons on our slow freight trains, and then com-

menced to cut it down. Finally, after a year of experimentation, we found we were hauling about 1,900 tons on these trains, and the reason that the cut was made was that the overtime became so great we had to reduce the trainload in order to avoid the overtime. As we studied the situation we had impressed on us the fact that the distances between sidetracks on a single-track line was a matter of very great importance to consider. We took records of the movement of trains at different points, where they entered sidings and where they did not enter sidings. We found that 20 minutes at least was lost by a train entering and leaving sidings, cutting out the time the train was not moving on the siding. In considering the whole question of grade reduction it seems to me that this question must come up for consideration. Should the passing sidings be 5, 4 or 7 miles apart, or what is the distance which will enable you to make the maximum use of the grades which you have? If you have a double-track line you have a question entirely different from that of the single-track line on the maximum grade. With a grade of 0.3% we would have been able to secure the maximum benefit from that, if we had a double track instead of a single track, because then our trains would not be obliged to enter sidings so frequently, and we could keep them moving. With a single-track line, we apparently would get the same results with a 0.35% grade as with a 0.3% grade.

Prof. Allen.—There is another element which might have entered into your experiment. Where a special experiment is made you are very likely to get much better results than you can get in ordinary practice.

Mr. Byers.—We did have that trouble. We had to be very careful to put someone to watch the brakemen to keep them from setting brakes on the train and showing us we could not get as many tons on the grade reduction as we believed we could get.

Mr. Ewing.—This brings up another question. The limit of safe length of trains is very often a governing feature. For instance, on our main line, from the coal regions to Philadelphia, our tonnage is 3,200. On certain tests, in order to see what the engine could pull, we pulled 5,400 tons. The length of the train largely governs the load in this case.

Mr. H. G. Kelley.—Here is an experience I had in making an actual test. The train stalled on the ruling grade. I went forward and the engineer said: "This momentum grade won't let me go." I said: "Pick up and we will get off this all right." He could not make it. I hauled out a profile of the road, showed him that the momentum grade was two miles behind, and then said: "What is the matter, why don't you go ahead?" He then opened the throttle and went up the hill.

Mr. Berry (Rock Island System).—From statistics taken on a line from Omaha to Grand Island, a distance of 154 miles, single-track, there is 32% of the schedule time between the points lost in waiting on sidetracks. That was taken for three separate periods of a month and shows what it means to wait on sidetracks.

Mr. A. S. Baldwin (Ill. Cent. Ry).—What is the economical limit of grade reduction? We have shown very conclusively that it is possible to reduce the grade beyond the limit of economy. We are confronted by the fact that we want to reduce the grades as much as we possibly can, to secure economy.

Prof. Allen.—There was one point the committee desired to emphasize, and that is the different operating conditions on different railroads, or even different divisions of the same road, will oftentimes give different results. Special studies need to be made even on the same road of conditions on different divisions, so that whatever experiments are made on train resistances, for instance, might need to be made by the same road under different conditions for main line and for important branches; main line with no grades; long trains; for other lines with high grades, short trains. The different conditions of operation would necessarily have a good deal of influence over results that would be reached.

Mr. W. L. Breckenridge (C. B. & Q. Ry.).—The Burlington has spent a large amount of money in grade reduction in the last few years. The last work has been in reducing a 0.3% grade to 0.2% maximum and 1° curvature. We find on the 0.2% grade we expect an engine of 35,000 lbs. tractive power, which is about the type of heavy engine to pull 3,000 tons. Of course, this varies; 3,000 tons, with a heavily loaded train of coal, for instance, where the tonnage is in the minimum number of cars, can be hauled; if this tonnage is made up of empty cars the tonnage could never be pulled because the train would be too long for practical operation.

In regard to momentum grades, Mr. Calvert, the chief engineer of our company, brought to my notice the other day a very valuable point. We put in momentum grades to save money in one or two cases. On the division through the valley the heavy fills were about 20,000 yds., and the ruling grade was 0.3%, with only 0.1% momentum. Recently the track has been so bad on this fill that the trains have not been able to acquire any velocity, and in consequence the tonnage on quite a long distance has been cut down to a 1% basis. We thought perhaps we lost more money by hauling short trains over the piece of momentum grade than if we spent the money in the first place and put it on a 0.3% basis. The grades which have been operated on a 0.3% basis in past years have been operated this year on a 0.4% basis, and we hope that during this year the tracks will be in such condition that we can operate it again on 0.3% basis. Since the construction of that road the business has not been as large as anticipated and we have nothing to show the results of momentum grade constructed on that line. As far as I know, there has been no trouble in hauling the tonnage. The grades that have been reduced to 0.3% varied considerably from 0.8% to a little over 1%. The capacity of the engines on the 0.3% grades have all shown, as far as we have been able to operate the track, the expected capacity. We got the rating we expected. As I said before, we are operating this year on 0.4%.

Mr. C. C. Anthony (Pennsylvania Lines).—I do not know whether it is proper for a signal man to enter this discussion, but it occurs to me that the relation of signals to the movement of trains might have some bearing on the work of this committee. In dealing with the location of signals at interlocking plants, and for block signal purposes, we frequently have the superintendent's objection to the location of a signal at a certain point. Of course, a signal is usually located because it is sometimes necessary to stop a train at a point where the signal is placed. The superintendent says: "I cannot have a signal there, because if I stop one of my trains there it will not be able to start again." My suggestion is that possibly there is a chance for the committee in considering this question to take into account the necessary location of signals upon the grades, with a view of having the conditions such that the trains can be started again when they must be stopped.

Prof. Allen: In connection with the use of momentum grades, a picture that has presented itself to my mind is a road of dense traffic with automatic signals which occasionally get out of order, and it has seemed to me that under those conditions a momentum grade would be very likely to turn out almost an unmixed evil, but momentum grades under favorable circumstances where the traffic is not dense may be very desirable. The committee on "Roadway," of which I was a member at that time, before the creation of this present committee gave some attention to the subject of momentum grades, and was somewhat cautious in giving its approval to them. I think the position taken at that time was that momentum grades in new location should be used somewhat sparingly, or with a great deal of care; that in revising location momentum grades oftentimes might be undesirable, and it was a question of a choice of evils, short trains or the use of momentum grades, and in many cases momentum grades seemed to be advisable. My personal opinion still is that in new work the saving of a small amount of money certainly should not justify a momentum grade; that, if possible, the actual grades should be brought down, but in a revision of line there certainly are cases where the use of momentum grade seems practically a necessity.

Mr. H. G. Kelley.—The effect on operation on a line where the engines are loaded to their maximum tractive effort, is the same for a momentum grade at some distance from the terminals where there are no signals governing the movements, as would be observed on the ruling grades with signals on the ruling grade. I think the remarks of Mr. Anthony are well timed. I know of one particular case where an entire improvement was held up for some time because of inability to determine the proper location of the signals on the ruling grades.

Mr. M. L. Byers.—I can give you one example of the effect of the use of momentum grades. We have one division which has 0.6% maximum grade, and we propose to reduce that to 0.3% without changing a single grade from one end of the division to the other. We will simply change the location of the passing sidings. The grades at the sidings are practically dead level. The line passes through bottom lands, and the towns are on a slight elevation, and naturally the passing sidings have been placed at the towns. There is 0.6% grade leading from the low bottom land up to this little elevation, and there is just room in that between the two 0.6% grades, on either side of the town, to place the passing siding. By placing the sidings on the low grounds we get away from the 0.6% grade entirely. The grades are all short and there is no difficulty in operating the line as a dead level.

Mr. Baldwin.—Mr. Byers mentions a point well worthy of consideration. In considering grade revision, I have seen cases where if you would leave in the momentum grades you could see a nice earning on your investment, but if you took out momentum grades you could not see any earning on your investment at all. I have made it a practice in grade reduction to run over the division a test train carrying the maximum tonnage that was expected to be handled on the division after the grades were reduced, and making every stop that it could be possibly expected the train would have to make after the grade reduction, and wherever we could run momentum grades with a speed of 10 miles an hour, we left them. In not a single case have we had to reduce any momentum grades, and there is an actual saving of a very large amount of money. It may be that other conditions will arise, such as the placing of sidings, or interpolations of passing tracks, or location of water tanks, etc., that will necessitate stopping where the momentum grade may exist, and it must be borne in mind that the change can be made, but in the meantime the interest on the investment has been saved probably for a good many years. It is for that reason that I think the idea of momentum grades should be given careful consideration. I agree with Professor Allen that it is a risky practice on new work, and we have used momentum grades sparingly on new work, and never used them except at points where the need of momentum grades is noticeable, and they could be taken up at comparatively small expense.

ELECTRICITY AS A CAUSE OF FIRES.

The report of the Electrical Bureau of the National Board of Fire Underwriters for the first quarter of 1907 contains considerable interesting information for electrical men on the subject of fires from electrical causes. Only such fires are treated in the report as possess instructive interest, a large number of incipient blazes and "burn-outs" due to grounding of high voltage systems on building fronts, signs, awning frames, etc., being omitted.

While the amounts of the losses are not given in every case, it is of interest to note that those which are given total more than $2,217,000. Of this amount one fire alone, due to careless handling of an electric flat-iron, caused a loss of $1,250,000.

A perusal of the various other items throughout the report will impress the most casual reader with the excessive number of fires which were due to careless practice in installation and wiring; such causes as the omission of a bushing at the sharp edged outlet of a service pipe, omission of drip loops from 1,100 volt primary wires at the transformer on a frame residence, improperly made and scantily taped joints allowed to lie upon the upper surface of a metal ceiling, a switch too small to carry the load imposed upon it—these and sundry others of a similar nature afford much food for meditation upon the old theme that eternal vigilance is the price of safety, and never more so than in electrical installation. A common sense of thoroughness and adherence to the specifications of the National Electrical Code would have reduced this quarter-year of losses to a very small fraction of the amount previously mentioned.

Then, also, there were the disasters resultant from—let us say—the absence of ability to make electrical service absolutely "fool-proof." A case is cited where a temporary lamp cluster in a dining room was festooned with inflammable cloth, which the heat of the lamps set afire; another is cited where a home-made bed warmer, fabricated by some genius from No. 22 B. & S. copper wire woven into a mat with woolen cloth, was allowed to overheat and ignite the bed coverings, thereby severely burning its aged occupant; a $3,000 fire was caused by the wrapping about a steam pipe of a flexible conducting cord, the insulation becoming brittle and allowing a short circuit to occur.

Brief mention is made at the end of the report of a phenomenon frequently noticed in this country, and reported also from Australia by Mr. John Hesketh, Electrical Engineer for the State of Queensland; that is, the boring into lead cable sheaths by insects—the larvae of the beetle *Dermestes Vulpinus*. Trouble from this cause was reported from the Union Stock Yards at Chicago, in the lead sheaths of the cables carrying the signal circuits—the trouble being confined to the "hoof" room, where hoofs are stored before being forwarded to the glue works, forming excellent feeding places for the insects. Cases were found where the lead sheath was almost entirely eaten away; but even if the damage were confined to the puncturing of the sheath and no more, the admission of moisture thereby would lead to trouble.

THE STEAMSHIP "DAKOTA," one of the largest vessels ever launched, which on March 3 went ashore in the Bay of Tokio, is reported to be beyond hope of salvage as the hull is broken in two. The "Dakota" was one of two sister ships built to carry the Oriental traffic of the Great Northern Ry. A very complete description appeared in our issue of Sept. 1, 1904.

IMPROVEMENTS ON THE CHICAGO DIVISION OF THE CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY.

The importance and extent of the railway improvement work which has been a marked feature of railway engineering during the past few years is reviewed in our editorial columns this week. A good example of railway improvements of the character under consideration, including various classes and kinds of work, is afforded by the Chicago Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry. Extensive improvements on this line have been made necessary by its great increase of traffic, and a recent trip over the work was made by a member of the editorial staff of Engineering News. For plans, information and general courtesies we are indebted to Mr. W. M. Duane, M. Am. Soc. C. E., Chief Engineer, and to Mr. H. H. Knowlton, Division Engineer, and Mr. W. M. Vandersluis, Signal Engineer.

The Chicago division extends from Cincinnati, O., to Kankakee, Ill., 249 miles; included in this are 17 miles of tenant line of the Lake Erie & Western Ry., near Lafayette, Ind. From Kankakee the trains are run into Chicago over the Illinois Central Ry., 56 miles. This division is shown on the map, Fig. 1, by a heavy line, the lighter lines representing other portions of the railway company's system. The work has been in progress since 1903, and will be practically completed during the present year. The total cost of the work will be about $4,000,000, of which 90% will be represented by the improvements between Cincinnati and Indianapolis. The principal improvement works are described below, and their general results are summarized in the accompanying table, an examination of which will show the important results obtained.

CINCINNATI TERMINALS.

While no improvements of importance in either passenger or freight facilities have been made at Cincinnati, it may be of interest to call attention to the numerous projects for a new union passenger terminal station, principally to afford better facilities for passengers, but partly also to avoid the recurrent interference with traffic due to the flooding of the present station at periods of exceptionally high-water in the Ohio River. In January last, at the time of the inspection trip above noted, the water rose to such a stage that the railways were compelled to abandon the Union Station, and to use the small outlying station at Eighth St., with consequent inconvenience and delay of all passengers. The same trouble was again experienced in March.

The present station is owned by the Union Depot & Ry. Co., in which the C., C., C. & St. L. Ry. is a majority holder. A number of plans have been proposed for a new station, some by the railway interests and some by independent companies; in most cases they provide for an underground line across the city (with a central station) to connect the lines entering at the east and west sides, which are at present connected only by freight tracks along the streets near the levee. Beyond the present station the line runs for some distance through a narrow congested throat in a cut, this part being known as "the ditch," and improvements here are difficult to effect except by extensive and costly reconstruction, which is not likely to be undertaken until some definite policy has been adopted in regard to the passenger and freight terminals.

CINCINNATI TO INDIANAPOLIS.

CLEVES TO LAWRENCEBURG JUNCTION. —From Cleves (16 miles west of the Cincinnati terminal) to Lawrenceburg Junction, 22.3 miles, the original line followed the bed of an old state canal, and although the ground is quite level the line was in places extremely crooked. For about 1½ miles this line has been relocated for the purpose of eliminating the unnecessary curvature and giving a direct line. In the table there is noted a maximum grade of 0.4%; this is very short, and is made necessary by a town ordinance and by the high-water mark of the Miami River. From Cincinnati to within one mile of Cleves the line runs west and is close to and parallel with the bank of the Ohio River. From this point it leaves the Ohio River, cuts through a high ridge dividing the Ohio and Miami valleys, and crosses the Miami and Whitewater rivers, still holding an almost level grade.

LAWRENCEBURG JUNCTION TO SUNMAN. —At Lawrenceburg Junction the line leaves the Miami River valley and turns to the north into the narrow and crooked valley of Tanner's Creek, which it follows as far as Sunman, 40 miles from Cincinnati. When the original line was built, in 1850, it was located with a view to low cost of construction, and the valley of the creek was followed as affording an easy route from the Ohio River valley to the higher country. The line kept close to the windings of the creek, sharp curves being freely used, and the grade followed very closely that of the water. The necessary rise of 500 ft. to the Indiana plateau was made in 17 miles. To get into the Tanner's Creek valley, the line crossed over a hill or ridge with 1% grades, and had a rise of 42 ft. and a fall of 35 ft. Beyond this, and beginning at Guilford, there was a grade of 1.25%, for 11½ miles, and here a pusher engine was employed on a run of 12 miles from Guilford to Sunman to help all fully loaded freight trains and some heavy passenger trains. It also frequently helped them over the 1% grades of the Lawrenceburg Junction cut-off. This cut-off was built in 1877, the original line having been located through Lawrenceburg, which is now reached by a branch.

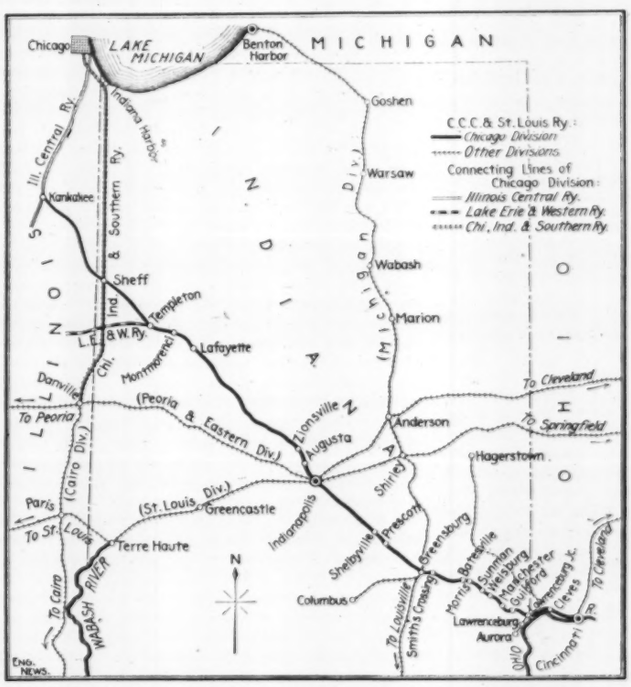


FIG. 1. MAP OF THE CHICAGO DIVISION OF THE CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY.

With the heavy traffic of recent years, and with the fast passenger trains and heavy freight trains of modern railway service, the line proved uncomfortable for passengers, expensive in operation and expensive in maintenance. In 1902, therefore, the railway company authorized the improvement of the line to Sunman, and on investigation it became very evident that, instead of rectifying and modifying the old location, the best results could only be obtained by making an entirely new location based upon the requirements of the operating conditions. In the 18 miles from Lawrenceburg Junction to Sunman, the new line crosses the old one at several points, but follows it only in two places and for a total length of less than a mile, at practically the same elevation as the former line. The surveys showed that Tanner's Creek valley afforded the only available route between the Ohio River valley and the Indiana table land; it was also found that, as the 500 ft. difference in elevation must be effected within this route, the grades could not be reduced so as to entirely eliminate the pusher grade. It was found practical, however, to reduce the rate of grade and to shorten the maximum grade from 11.5 miles to 7 miles, thus increasing the traffic capacity of the pusher engine, since with this shortened run the one engine could handle nearly double the number of trains and so handle the greatly increased traffic. The pusher grade as now built is 1.05% for seven miles, beginning at Manchester, with a total rise of 380 ft. From Guilford (the beginning of the old pusher grade) there is a grade of 0.5% to Manchester. The grades of the Junction cut-off have been reduced to 0.5%, which can be surmounted without the aid of a pusher by any train that can be hauled over the division, so that the service of the pusher engine is confined to its regular seven-mile run. The maximum curve is of 2°, except that the cut-off is on a 2½° curve, with a central angle of 121°; this takes the place of a 5°50′ curve on the original location.

The relations of the alinement and grades of the old and new lines on this section are clearly shown in Fig. 2. It will be seen that two long sags in the old location are replaced by stretches of line at a higher level on the hill side and with an easier and more uniform grade. This part of the line, therefore, was entirely rebuilt, but under the difficulties and delays incident to the necessity of avoiding interference with the old line at the numerous points where it was intersected. The work was commenced in August, 1903, and the line was opened for traffic on the new location in February, 1905.

The heaviest work on the entire division was comprised within this section, owing to the hilly character of the country, the winding course of the valley and the numerous ravines which run into it. The old line crossed the creek 22 times, while the new one crosses it only 16 times. Near Manchester (mile post 33) the creek has been diverted into a channel about 1,000 ft. long, thus eliminating two bridges which would otherwise have been required to cross a loop in the nat-

IMPROVEMENTS ON THE CHICAGO DIVISION: C., C., C. & ST. L. RY.

Location.	Dist. from Cincinnati. miles.	Date of Improv't.	Length (new) miles.	Saving in distance. ft.	Total curvature. Old. deg. min.	Total curvature. New. deg. min.	Saving in curvature. deg. min.	Max. curve. Old. deg. min.	Max. curve. New. deg. min.	Max. grade. Old. p.ct.	Max. grade. New. p.ct.
Cleves to Lawrenceburg Jn.	22.30	1905	6.22	339	158 25	25 58	132 27	5 00	2 00	0.50	0.40
Lawrenceburg Jn. to Sunman	39.90	1904-05	18.11	6,800	2,291 00	781 00	1,510 00	5 50	2 30	1.25	1.05
Sunman to Morris	45.30	1906	4.66	None	19 47	19 47	None	2 00	0 30	0.75	0.30
Morris to Batesville and Block Sta. "J.B."	50.70	1905	5.64	640	158 00	64 00	94 00	5 15	1 00	0.80	0.40
"J.B." to Cobb's Fork	57.00	1906	6.25	None	34 48	34 48	None	3 30	1 00	0.70	0.30
Cobb's Fork to Greensburg	62.90	1904	5.89	1,320	257 57	32 48	225 9	5 00	1 00	0.85	0.50
Prescott to Shelbyville	84.30	1906-07	5.30	None	140 47	140 47	None	0 30	0 20	0.80	0.40
Indianapolis to Augusta	120.60	1906	5.87	700	195 53	81 53	114 00	5 15	2 30	0.75	0.40

ural channel. This new channel is a rough rock cut about 30 ft. wide at the bed of the stream, 45 ft. deep at the point of greatest cut. It has practically vertical sides. At its upper end is a small concrete dam or weir forming a pond which serves as a reservoir for a water station located two miles down the creek; this dam is fitted with sluice gates. Many of the long side hill banks have the slopes reaching to the creek, and these are protected by rough riprapping with large quarry blocks, as the creek is subject to sudden and violent floods in the winter and spring, while the current is very swift and turbulent at high water. Some of the heavy cuts are 50 to 80 ft. deep on the center line, or even as deep as 100 ft. at the upper slope. Some of these are in a shattered or disintegrated gray shale rock, which does not slide, but stands well on a slope of 1 to 1. The slopes of the banks are generally 1½ to 1. All wet cuts have 8-in. tile drains laid under the side ditches. In an article in our issue of March 16, 1905, it was stated that a cut at Guilford was 125 ft. deep and another at Weisburg 93 ft. deep, while a single mile between Weisburg and Manchester cost $370,000, having three cuts and three bridges. Near the southern end of this section, a soft clay has been used for some of the banks, and has shown a tendency to settle and slide, so that in some cases rows of piles have been driven at the middle and toe of the slopes in order to hold the bank.

At two points also, there has been trouble with the caving of slopes in sidehill cuts. The material is a wet yellow clay and lies on a stratum of a species of soapstone. Water reaching the latter through cracks due to the movement of the clay body towards the cut makes a smooth lubricated surface upon which the clay slides. The conditions are very similar to those described in an article on "Railway Construction through Sliding Ground in France," in our issue of Sept. 13, 1906. In both cuts double rows of piles have been driven near the toe of the slope, the rows being 8 ft. apart and the piles also 8 ft. apart (staggered). In one case, where the cut is about 40 ft. deep, the signs of movement of the ground are apparent nearly a quarter of a mile distant, and special means have been taken to check this movement in order to protect a house and a public road on the hillside. The road is now held by two rows of piles on the lower side, with brush woven between them and a filling of cinders put in to prevent the material from flowing away between the piles. The piling at the toe of the other cut proved to be insufficient and piling has now been driven at about the middle of the slope. The clay stands at a slope of about 1½ to 1 in the cuts, and some stone drains have been laid up the slope to collect surface water and check washing and sliding. It has been suggested that the soapstone stratum might be broken up by light charges of dynamite, so as to destroy the smooth sliding surface and bond this stratum with the clay. It is probable, however, that the explosions would themselves start heavy slides in the mass of wet clay.

SUNMAN TO MORRIS.—On this stretch of line, 5.4 miles, there is no change in alinement, but the profile has been improved by raising banks and deepening cuts, thus eliminating humps and sags, and not only reducing grades but giving a more even grade line, adapted to the better handling of trains. On this work, the material excavated by the steam shovels was handled by 6-yd. four-wheel side-dump Western cars, and spreader cars were used to level off the material and finish the banks to grade. The work on this section was done by the Southern Contracting Co., of Ludlow, Ky., and was completed in February, 1907.

MORRIS TO BLOCK STATION "J-B."—At Batesville, three miles west of Morris, there is an important change in alinement, which is shown by Fig. 3. The old line had several curves and ran along the main street of Batesville on the street level, which was of course a very unsatisfactory arrangement for modern conditions of traffic. The new line is more direct, keeps some distance back from the town, and effects a saving in distance, grade and curvature. It was put in operation in July, 1906. The general contractor was W. J. Oliver, of Knoxville, Tenn.

BATESVILLE TO GREENSBURG. — The stretch of the line from the "J-B." block tower to Cobb's Fork, 6.2 miles, has no change in alinement, but the profile is greatly improved for operating conditions. The character of the work is very similar to that between Sunman and Morris, noted above, and the characteristics of the old and new lines are shown in the table.

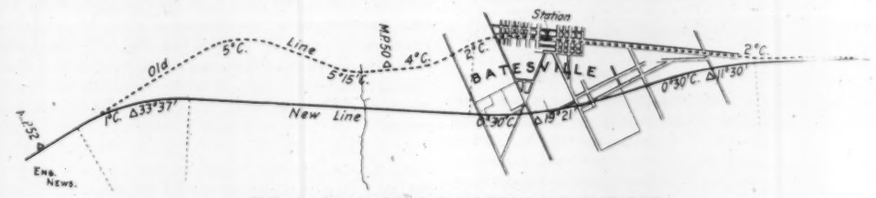


FIG. 3. PLAN OF THE BATESVILLE CUT-OFF.

From Cobb's Fork to Greensburg, however, there is a new cut-off, shown by Fig. 4, which gives a direct line, with few and easy curves and very much easier grades. This was built by the A. J. Yawger Co., of Indianapolis, and was completed in August, 1904.

PRESCOTT TO SHELBYVILLE. — From Greensburg to within a mile of Prescott (77.3 miles from Cincinnati) there is no material change, but at this point begins an important improvement of grades on the original location. The old line followed the surface of the country pretty closely, while the new one involves heavy cuts and banks in securing a more uniform and favorable profile. At one of these banks, in wet material, a 12-in. tile drain is laid in a trench, near the toe of each slope, in order to keep the ground well drained. The excavation was done by steam shovels, the material being handled in 12-yd. Western side-dump cars, mounted on trucks and fitted with air brakes, so that the dump-car trains could be hauled as ordinary work trains. A spreader car and a road-grading machine were used to level off the banks and to finish the roadbed to grade in the cuts and banks, ready for the ballast. This work was done by the F. H. Blodgett Co., of Wheeling, W. Va., and was completed early in 1907.

The reconstruction upon the original location has involved the exercise of considerable ingenuity in enabling the regular traffic, the construction trains, and the work generally to be carried on without undue delay. A continuous running or main track was kept open at all times, the track being shifted and connections made or cut as needed to allow work to proceed. This required the employment of large gangs of men to move the track and keep it open for traffic. The distribution of ballast was done by the railway company's trains and forces, and all track work was done by special gangs, the contractor having only to complete the work to subgrade.

SHELBYVILLE TO INDIANAPOLIS.—There are no material changes in the main line on this section, but near Indianapolis sites are being graded for very extensive freight yards and for large building and repair shops serving the locomotive and car equipments of all the divisions of this railway. A small winding creek crosses the site of the shops, but this will be diverted into a concrete culvert, which will receive the drainage from the plant. Additional tracks will have to be laid here to provide for the construction and material trains, and later to serve as the entrance to the shop and yard systems.

INDIANAPOLIS AND AUGUSTA.—A very interesting change of line has been made on the line leading out of Indianapolis. This is shown in Fig. 5. The road from Cincinnati enters the city in a northwest direction, and runs west into the Union Station. A little distance beyond the station the main line of the Chicago Division turns north along North Missouri St. and Lafayette St. to Seventh St., where it changes to an approximately northeast direction, through North Indianapolis (3.5 miles), and across the

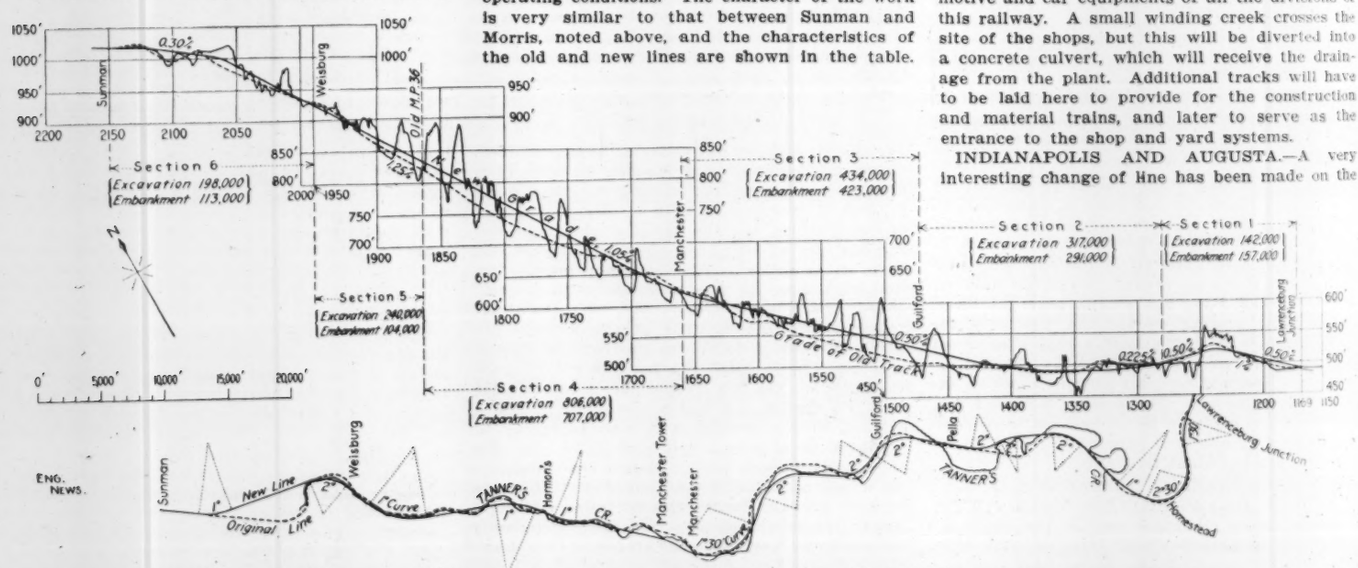


FIG. 2. PLAN AND PROFILE SHOWING IMPROVEMENTS BETWEEN LAWRENCEBURG JUNCTION AND SUNMAN.

White River. The Peoria Division runs west from the station, crossing the river in a short distance, and the freight traffic has for some time been kept off the Missouri St. main line by being handled over this division and the Belt Ry., which intersects the Peoria Division on the west side of the river and unites with the main line at North Indianapolis. This, however, was not a favorable line for operating. An entirely new main line, known as the Crooked Creek

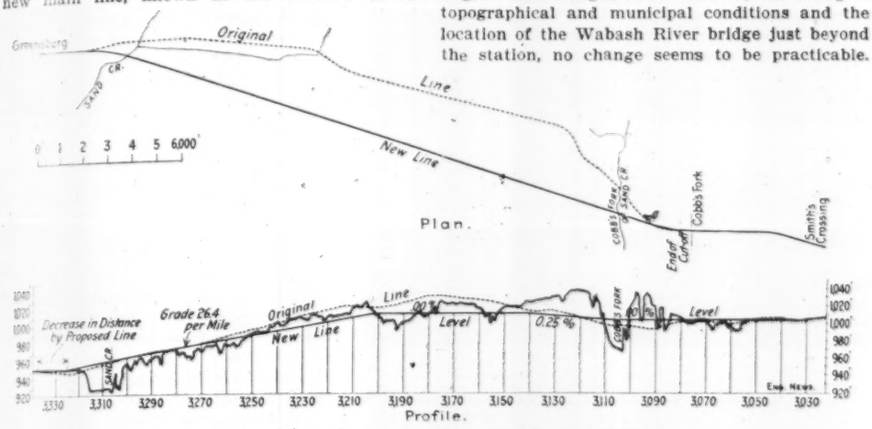


FIG. 4. PLAN AND PROFILE OF THE GREENSBURG CUT-OFF.

cut-off, has therefore been built, starting from a junction with the Peoria Division beyond the Belt Ry. connection and having a continuous tangent of five miles extending due north to Augusta, on the Chicago Division, ten miles from Indianapolis. This gives a straight line with easy grades, the maximum being 0.40% as compared with 0.75% on the old line. It has also the advantage of being outside the city and removing all main line traffic from the built-up districts. This is especially important in view of the track elevation work now being demanded by the city, and referred to later. The elevation of the Missouri St. line would have been very expensive, with numerous bridges, and would have seriously interfered with the numerous industrial spurs to manufacturing plants. Some 20 bridges would have been required, while on the new line only two streets have to be bridged. With the new cut-off in operation, the Missouri St. line has been abandoned to industrial and local freight purposes, so that its elevation will not be required. That portion of the Belt Line between North Indianapolis and the Peoria & Eastern Ry. was maintained and used exclusively by the C., C., C. & St. L. Ry., but since the opening of the new line, in July, 1906, it has been turned over to the Indianoplis Belt Ry.

INDIANAPOLIS AND KANKAKEE.

With the exception of the Crooked Creek cut-off, just mentioned, there have been few changes on the line north of Indianapolis, this part of the Chicago Division being in general favorable. Two pieces of work, however, are noted below.

ZIONSVILLE.—At this point, 15 miles from Indianapolis, a relocation and reduction of grade is projected, and may be made next year.

LAFAYETTE AND MONTMORENCI.—The road enters Lafayette, 64 miles from Indianapolis, over the Lake Erie & Western Ry., by a very long curve of 10°, with 67° of central angle. This is right at the station, but owing to topographical and municipal conditions and the location of the Wabash River bridge just beyond the station, no change seems to be practicable. Formerly the curve was sharper than at present, to avoid the adjacent right-of-way of the Lake Erie & Western Ry., but by a merging of passenger and freight facilities with the latter the conditions were much improved to the advantage of both roads. From Lafayette north to Templeton, 17 miles, this road uses the line of the Lake Erie & Western Ry., under the usual form of contract governing such tenancy. On this stretch of line, from the north end of the Wabash River bridge at Lafayette, and extending to Montmorenci, 9 miles, the grades are being reduced on the original location, preparatory to double tracking. This involves raising the banks and deepening the cuts, and widening both cuts and banks. In lowering the grade, a narrow cut is made along one side for a temporary main track, and when this is in service the steam shovel starts a similar cut on the opposite side. The earth is loaded into dump cars running on a narrow gage track laid on the old grade and alongside the old main track. Mr. Robert Grace, of Cleveland, O., is the contractor. This work will be completed during the present year.

CHICAGO TERMINALS.

As already noted, the Chicago Division proper ends at a connection with the Illinois Central R. R. at Kankakee, and the Cleveland, Cincinnati, Chicago & St. Louis Ry. uses the passenger and freight terminals of this railway in Chicago. Since the construction of the Chicago, Indiana & Southern Ry., and its acquistion as a part of the system of the New York Central Lines, there is available a new route into Chicago, as shown by Fig. 1. The use of this would bring the C., C., C., & St. L. Ry. into the La Salle St. terminal station, which is now used by two other New York Central Lines (the Lake Shore & Michigan Southern Ry. and the New York, Chicago & St. Louis Ry.). However, the Michigan Central Ry., which is also included in the New York Central Lines, now uses the Illinois Central Ry. terminals, and there is apparently no intention of making any change in the present arrangement, by which the four lines are distributed between two separate terminals.

DOUBLE TRACKING.

On the sections where improvements have been made a double track has been built, and it is expected that within about two years there will be a continuous double track between Cincinnati and Indianapolis, which section has a heavier traffic than that between Indianapolis and Chicago. On single track portions there are two passing sidings about 4,000 ft. long, at intervals of six miles.

BLOCK SIGNALING.

The entire length of the Chicago Division is operated under the block system, being equipped with manual-controlled semaphore signals. The blocks have an average length of about five miles. The distant signals are usually 2,500 ft. in advance, when operated by wire, but there are some electric signals placed 3,500 ft. in advance. The latest installations of electric distant signals are of the semi-automatic type. The semaphore arms are red with a white stripe for the home signals, and yellow with forked end and forked black stripe for the distant signals; they have a travel of 90°, hanging vertically to indicate "clear." The colors for night indications are red and green for the home, and yellow and green for the distant signals. On single track, the block stations are arranged at passing sidings, the sidings being about 4,000 ft. long.

The block system is also used during reconstruction, to facilitate the prompt and safe movement of regular traffic and construction trains. For this purpose, temporary block stations are established as required where the work is in progress.

At passing sidings, the outgoing ends are largely controlled from the adjacent block tower. There is no permissive blocking. At times, to prevent serious blockade, one freight train is permitted to follow another into a block under a special "proceed" order issued by the dispatcher. A freight train is never permitted to follow a passenger train, or one passenger train to follow another into a block. These proceed orders are only for emergency use. There are 14 steam railway grade crossings equipped with interlocking plants, and also one interurban electric railway grade crossing similarly equipped. All main track facing-point switches are protected by high switchstands, and where these switchstands cannot be seen for at least one mile, mechanical or electric semaphore distant signals are erected. The interlocking plant at the junction at Kankakee is operated by the Illinois Central Ry.

It is also to be noted that a special feature of the line so far reconstructed is that there is only one facing point switch not protected by an interlocking plant between Greensburg station and Mill Creek Yard, the latter being within two miles of the Cincinnati station. This one switch is for eastward movements and is protected by an electric semi-automatic signal. For westward movements there are two switches, each of which will be similarly protected in a short time. Either one of the switch signals showing the

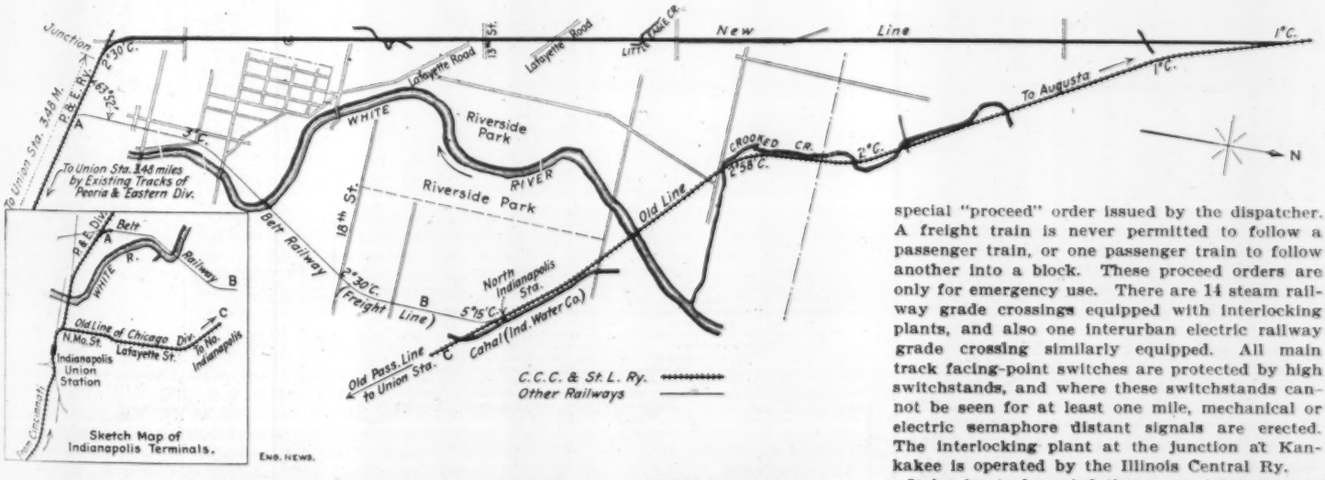


FIG. 5. MAP OF INDIANAPOLIS TERMINAL LINES AND CROOKED CREEK CUT-OFF.

position of the switch may be seen from approaching trains at a distance of one mile.

TRACK CONSTRUCTION.

The 249 miles of line include in the aggregate 91.2 miles of double track, leaving 157.8 miles of single track with 25 miles of passing sidings. The minimum width of roadbed is 40 ft. in cuts and 33 ft. on banks: the main tracks are laid

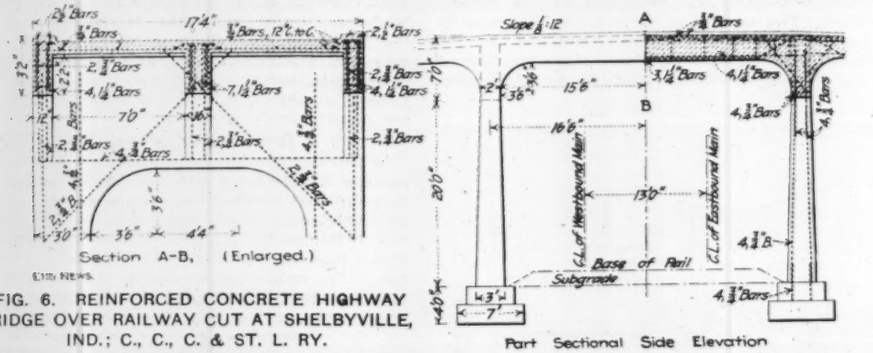


FIG. 6. REINFORCED CONCRETE HIGHWAY BRIDGE OVER RAILWAY CUT AT SHELBYVILLE, IND.; C., C., C. & ST. L. RY.

13 ft. c. to c., with sidings 16 ft. c. to c. from main track. All curves of over 1° are spiraled. The superelevation of curves is ordinarily made to suit a speed of about 65 miles per hour. At connections to passing sidings, the turnouts have leads of 79 ft. and No. 10 frogs. At the ends of double track sections the lead is 172 ft. and the frog No. 24, giving a curve of 1°, in order to prevent unpleasant lurching or swaying of cars in trains running through at high speeds. All main track switches have semaphore home and distant signals, and are controlled from block towers except at yards, and the outlying switches of passing tracks. On double tracks, all facing switches are eliminated where practicable.

The rails are of the 90-lb. Am. Soc. C. E. section, in 33-ft. lengths, laid with broken joints of the three-tie supported type which has been used on the New York Central Ry. for several years, but not adopted by many other roads. The joints have six-bolt splices, with bars 36 and 42 ins. long; the rails are drilled with a spacing of 3½ ins., 6 ins. and 7 ins. c. to c. in both cases, and the different lengths of bars are be-

The ballast is of gravel, not less than 12 ins. deep under the ties. This is obtained from a large pit near Cincinnati, and is clean and coarse in quality, well adapted for the purpose. It is distributed by 100,000-lb. Hart-Rodgers convertible center-dump ballast cars, the gravel trains consisting generally of a 101-ton consolidation engine and 18 of these cars. A car fitted with a flanger is supposed to accompany the train, but does not always do so for various reasons. With its use the unloading of the cars is much facilitated, but when it is not used some trouble is experienced in properly distributing the material. If too large a quantity is deposited between the rails, the only way of leveling it is to chain a tie to one of the cars, so as to ride on the rails just ahead of the front truck. This is an awkward and makeshift method, however, and is liable to lead to derailment unless carefully watched. Preference is expressed for side-door dump cars which discharge the entire load when the doors are released. All ballasting and track work is done by the railway company's forces and equipment, under the direction of the Division Engineer.

TRACK ELEVATION AT INDIANAPOLIS.

After several years of discussion and preliminary negotiations, the city of Indianapolis has adopted a policy of requiring the elimination of grade crossings, to be effected mainly by elevating the railway tracks, the streets being depressed to some extent so as to reduce the amount of elevation required. The city pays 25% of the cost of the work, the railways 75% being paid by the railways. The Chicago Division of the C., C., C. & St. L. Ry. has been elevated for about one mile in order to cross Massachusetts Ave. and Tenth St. The work is of the usual character, with concrete retaining walls and abutments and earth filling, while plate-girder solid floor ballasted bridges carry the tracks across the streets. Under the ordinances this may have to be extended to the avoidance of the necessity of elevating the original main line by building a cut-off has already been mentioned.

NEW SHOPS AT INDIANAPOLIS.

The new shop plant for the maintenance and repair of locomotives and cars of all the divisions centering at Indianapolis has been planned on a very extensive scale, and so arranged that certain buildings may be erected to meet present requirements and then systematically extended from time to time, while preserving the uniformity of the plant as a unit. The plant and machinery equipment have been designed by the Arnold Co., of Chicago, in accordance with the general plans and requirements of Mr. Wm. Garstang, Superintendent of Motive Power. The plant is at Beech Grove, about five miles south of Indianapolis, and is designed to care for about 200 locomotives, with 100 engines handled for heavy repairs each month.

The site has been partly graded, and three shops are under contract: erecting shop (315 x 578 ft.), boiler shop and forge shop. Later on there will be the car shops, including a passenger car repair shop and paint shop, each 177 x 442 ft. and fronting on a transfer-table put between the two buildings; the freight car repair shop will be located near the repair tracks. The boiler shop and the ends of the erecting shop, forge shop and car shops will front on a yard or roadway 75 ft. wide, having railway tracks and a 10-ton yard crane with a runway 2,000 ft. long. The arrangement of the erecting shop is somewhat novel. Along each side will be a bay 70 ft. 6 ins wide, and 50 ft. high to the

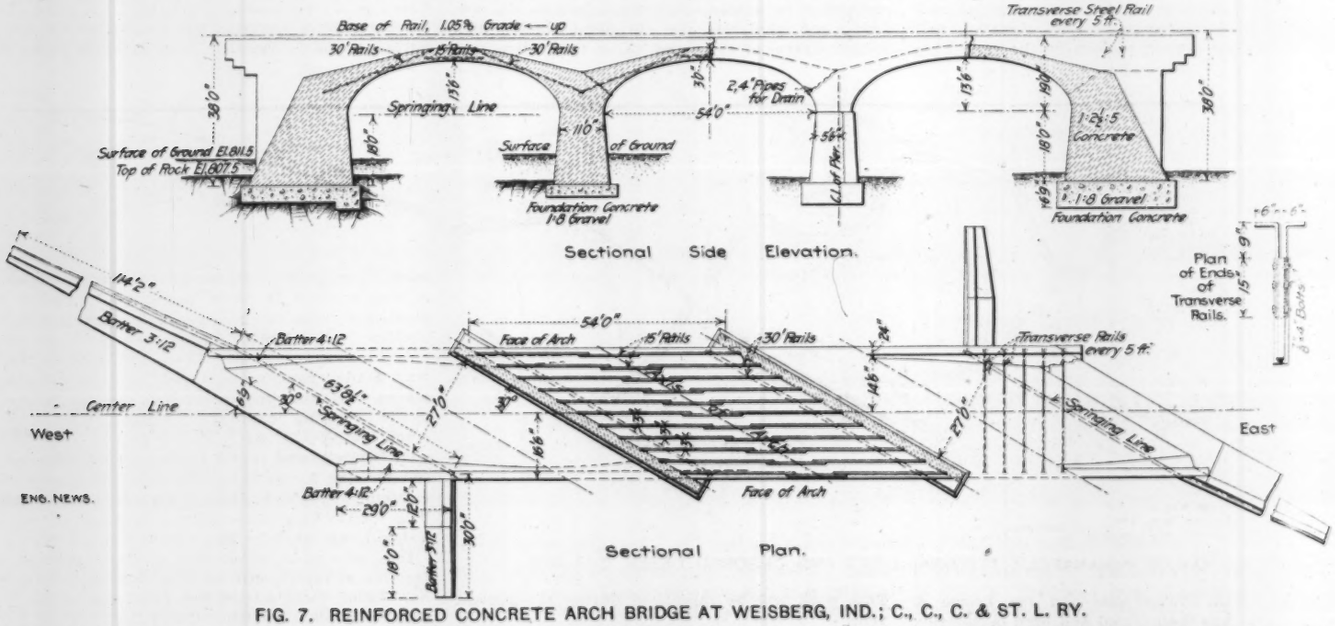


FIG. 7. REINFORCED CONCRETE ARCH BRIDGE AT WEISBERG, IND.; C., C., C. & ST. L. RY.

ing used for experimental purposes. This construction takes the place of 80-lb. rails with six-bolt 32-in. splice bars. About half of the ties are of creosoted timber, treated by the Columbia Creosoting Co., at Shirley, Ind.; this plant was described in our issue of Sept. 13, 1906. There are 20 ties to a 33-ft. rail.

roof trusses; these will have pits for the engines, a 10-ton crane 28 ft. above the floor, and above this a 120-ton crane by which engines can be carried to and from the pits. On the inner side of each of these bays will be a 65 ft. bay, 35 ft. high, with 10-ton cranes, and the 40-ft. space between these will be for the lighter machinery.

with a gallery above for the copper shop, lavatories, etc. The two side bays will have triangular roof trusses and monitors; the three inner bays will have a saw-tooth roof carried by shallow parallel-chord trusses. The buildings will be of steel frame construction with brick walls.

INDIANAPOLIS FREIGHT YARDS.

Extensive freight yards have been planned adjacent to the shop plant, providing for the handling of about 3,000 cars per day; they will cover about 470 acres and have some 140 miles of tracks. They will be arranged in duplicate for north and west bound traffic and for south and east bound traffic, each set comprising a separating yard, classification yard and departure yard, together with a hump for gravity switching. In connection with the yards and shops there will be two 25-stall roundhouses, a coaling station, and other facilities for the care of locomotives in service.

BRIDGES.

All the culverts up to 4 ft. diameter are of cast-iron pipe, with concrete end walls; those of larger size are of concrete. Ordinary country roads are crossed by reinforced concrete arches of 20 to 30 ft. span. At two or three points highways will be carried over the railway by reinforced concrete girder bridges. One of these, at Shelbyville, is shown by Fig. 6. It is designed for a live load of 300 lbs. per sq. ft., which is ample for a traction engine. There are several important bridges having three or more spans of reinforced concrete arches. An example of this class of structure is the Welsburg bridge, shown by Fig. 7. One interesting feature is the use of old rails for the longitudinal and transverse reinforcement. This has proved entirely satisfactory. It will be seen that in each side of the arch ring is a row of 30-ft. rails, 3 ft. apart, placed in an inclined position; at the crown of the arch, and near its intrados, are 15-ft. rails, not connected with the others. The transverse rails are 5 ft. apart, and have bent plates bolted to the ends to form anchors. In other structures of this class steel rods are employed for the reinforcement. Notes on the bridges on this work were given in our issue of March 16, 1905.

In some of the earlier concrete bridges natural cement was used in the foundations, but all concrete work is now made with Portland cement. While broken stone is preferred for the aggregate, gravel has been extensively used where stone could not be obtained in sufficient quantities to ensure the completion of the concrete work within the required time. However, the use of gravel has so far been confined to the concrete for footings, piers and abutments, stone being invariably used for the arch rings. The gravel is used as it comes from the pit, and contains from 33% to 38% of sand. The proportions of gravel concrete are 1 to 8. For stone concrete, the proportions are 1:2:4 for the arch rings, and 1:3:6 for other parts.

The only truss bridge is that crossing the Whitewater River, the steel structures being usually plate-girder deck spans on concrete piers. On the new work, the girders carry a solid reinforced-concrete floor, with 12 ins. of ballast under the ties. The top of the concrete is not extended over the chords, but asphalt filling is laid upon the steel. The construction (Fig. 8) is strong and economical, and the bed of ballast ensures an easy riding track. It may be noted that in none of these structures are guard rails provided, as is the general practice on the ordinary type of open-floor steel bridge; nor is any parapet provided. It would seem, however, that these safeguards should be provided on concrete and solid-floor bridges.

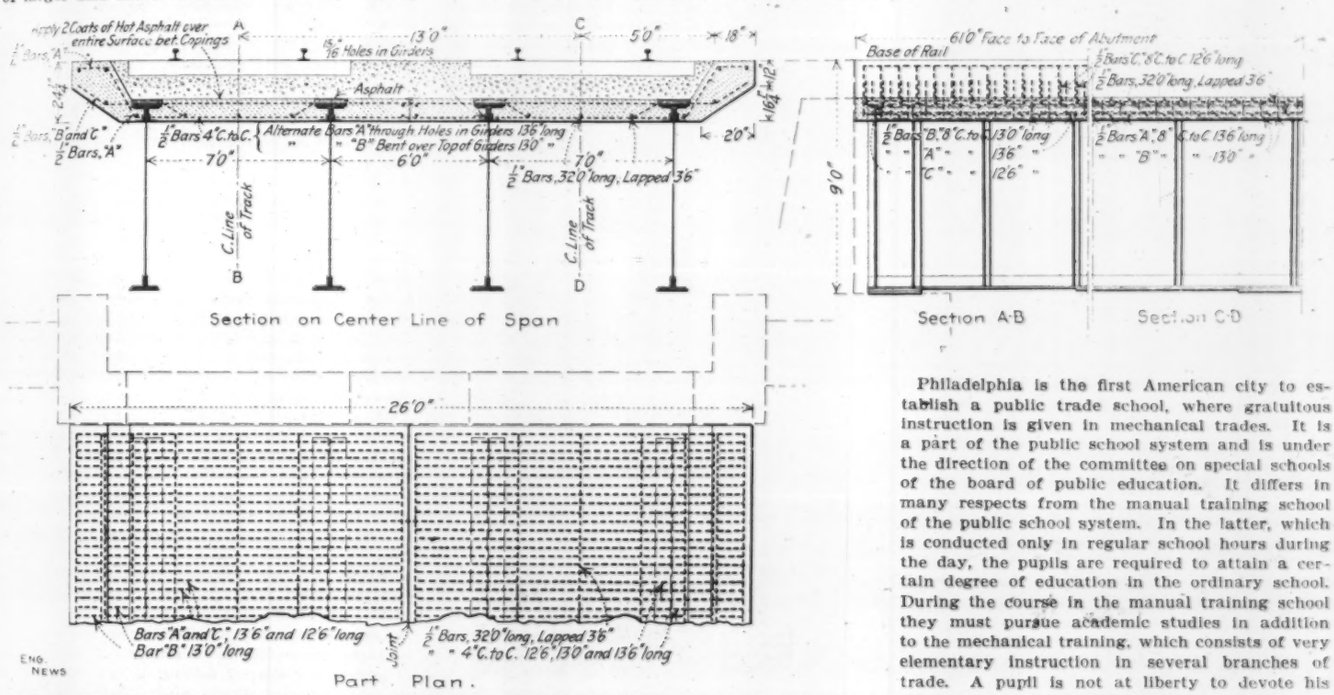

Apply 2 Coats of Hot Asphalt over entire Surface bet. Copings
13'0"
5'0"
18"
Asphalt
Alternate Bars "A" through Holes in Girders 136" long
" " "B" Bent over Top of Girders 130" "
7'0"
6'0"
7'0"
½" Bars, 320" long, Lapped 36"
C. Line of Track
Section on Center Line of Span
26'0"
Bars "A" and "C" 136" and 126" long
Bar "B" 130" long
½" Bars, 320" long, Lapped 36"
" 4" C. to C. 126", 130" and 136" long
Part Plan.
610" Face to Face of Abutment
Base of Rail
½" Bars "C" 8" C. to C. 126" long
½" Bars, 320" long, Lapped 36"
½" Bars "B" 8" C. to C. 130" long
" " "A" " " 136" "
" " "C" " " 126" "
½" Bars "A" 8" C. to C. 136" long
" " "B" " " 130" "
9'0"
Section A-B
Section C-D

FIG 8. REINFORCED CONCRETE FLOOR FOR PLATE-GIRDER DECK BRIDGES; C., C., C. & ST. L. RY.

RELATIONS OF IMPROVEMENTS TO OPERATING CONDITIONS.

The improvements noted above have greatly improved the operating conditions, notably through the valley of Tanner's Creek and at Indianapolis. On the section between Cincinnati and Indianapolis, the regular freight train of a 101-ton consolidation engine was formerly 1,650 tons, with a pusher for 14 miles and sometimes also at Lawrenceburg Junction. At present the regular load for the same class of engine is 2,250 tons, and the pusher grade is reduced to seven miles, while no pusher is required anywhere but on this grade. Thus the capacity of the one pusher engine is greatly increased, as already noted. On the section between Indianapolis and Kankakee, the improvements are of a minor character, and the regular freight train load is still 1,500 tons. As regards passenger service, the effect of the improvements is to greatly improve the safety and easy riding of the trains at high speeds, and consequently to make these fast trains more comfortable for passengers. The importance of this from a traffic point of view is evident when it is remembered that there are four competitive routes between Chicago and Cincinnati. There should also be a material economy in track and general maintenance work. The daily traffic is approximately as tabulated below; the figures include all extra freight trains, but not suburban trains or work trains. Since the opening of the new portions, the time of freight trains between Indianapolis and Cincinnati has been reduced about 30 minutes.

	Cincinnati to Indianapolis.	Indianapolis to Kankakee.
Through freight	26	22
Local freight	2	2
Through passenger	12	6
Local passenger	4	4
Total	44	34

THE PHILADELPHIA TRADE SCHOOL.

A prominent mechanical engineer once said, that the only plumber he had ever met with who had shown any desire to analyze the conditions for which plumbing was designed, and who had shown a spirit of investigation and original work was a graduate of a trade school. This statement is significant.

Philadelphia is the first American city to establish a public trade school, where gratuitous instruction is given in mechanical trades. It is a part of the public school system and is under the direction of the committee on special schools of the board of public education. It differs in many respects from the manual training school of the public school system. In the latter, which is conducted only in regular school hours during the day, the pupils are required to attain a certain degree of education in the ordinary school. During the course in the manual training school they must pursue academic studies in addition to the mechanical training, which consists of very elementary instruction in several branches of trade. A pupil is not at liberty to devote his time to any one particular branch.

The trade school is conducted on entirely different lines. Any young man may enroll as a student or as an apprentice in the trade he desires to learn without any regard to academic attainments. All tools and materials are furnished. There are evening classes, the students in which are largely apprentices working at their trades during the day. The progress of such students is naturally rapid. The work of the men is advanced as rapidly as they develop skill, and the aim is to produce competent journeymen. The following classes are maintained with the attendance in each as indicated: plumbing, 45; pipe fitting, 13; blacksmithing, 11; sheet metal working, 51; electrical construction, 126; bricklaying, 37; pattern making, 28; house and sign painting, 33; architectural drawing, 24; mechanical drawing, 21; carpentry, 45; plastering, 14; printing, 33.

The above information is abstracted from a paper in "Domestic Engineering" of May 4.

THE MISSOURI RIVER at St. Joseph, Mo., is reported as likely to vacate its present bed and cut a new channel which would leave the city five miles away from the stream. Col. James B. Quinn, the local U. S. Engineer officer is quoted as stating that to avert the danger and protect the banks at St. Joseph would take the entire appropriation made for the Missouri improvement work this year.

HYDRAULIC EXCAVATION IN SEATTLE WITH A MOTOR-DRIVEN TURBINE PUMP.

By GEORGE HOLMES MOORE,* Assoc. Am. Inst. E. E.

One of the most interesting of the engineering problems of Seattle's rapid growth, is the grading and leveling of her hills. While apparently a field for civil engineering only, it affords also scope for both electrical and mechanical skill as is shown by the plant for the reduction of Denny Hill.

This elevation, some 60 ft. high, at the northern edge of the business district, is the site of the old Washington Hotel. This was one of the landmarks of Seattle and commanded an unmatched outlook on the Sound and the mountains beyond. It was, however, difficult of access from the business centers and is now being torn down to make way for the new million-dollar Washington which is already rising from the lower level.

Denny Hill was first attacked by the steam shovels the latter part of 1905. About the middle of September, 1906, a hydraulic giant using water from the city mains was introduced. Both these methods, even in conjunction, were slow and inadequate to the task of handling the hard

HYDRAULIC EXCAVATING FOR A BUILDING FOUNDATION IN SEATTLE, WASH.

blue shale forming the lower portion of the hill. A contract was therefore let for a pumping plant to take water from the sea, one of the conditions of which required the delivery of 3,500 gals. per minute with a pressure of 100 lbs. at the nozzle of the hydraulic giant.

As haste was essential, and the congestion of electrical manufactures offered no hope of speedy delivery, Caldwell Bros., who secured the contract, bought the required motor second-hand in New York City. This unit has been lately written up by the local papers as the largest electric motor north of San Francisco and west of Butte, and it is indeed the largest motor now in operation in the city of Seattle. It is an early Westinghouse synchronous type, designed to furnish 804 HP. at 2,400 volts and 60 cycles. As it seems amply capable of delivering 1,350 HP. under present ratings, it seems not improbable that it is better than a new machine of the same name-plate capacity.

The starting motor is a 40-HP. two-phase Westinghouse induction type, which takes current at 440 volts from transformers on the 2,200 volt mains. The exciter is a 10-KW. Edison bipolar of uncertain characteristics which will probably soon be replaced by a modern machine. As the motor runs at 330 r. p. m. and the turbine-pump at 500, direct connection was impossible, and power is transmitted by a 48-in. belt, 66 ft. in length.

Since the synchronizing of a machine of this size and type is always attended by some danger of disturbance to the supply system, it is undesirable to stop and start it at frequent intervals. On the other hand, it is frequently necessary to shut off the water to permit changing nozzles and moving the giant at the pit. A friction clutch was therefore introduced between the motor and the driving pulley which allows the motor to be stopped and started independently of the pump. This is also advantageous because it allows the motor to be brought up to speed under no load.

An interesting feature of this arrangement is that when the pump is stopped, the motor floats on the line with no apparent power-consumption, the ammeters in both phases indicating zero when the correct field excitation is obtained. This, of course, is due to the condenser characteristic of an over-excited synchronous motor.

The pump, which was specially designed for the purpose, is a four-stage Worthington turbine, guaranteed to deliver 3,500 gals. per minute under a pressure head of 180 lbs. at the pump. This pressure is the total required to cover the three items of static head, pressure head and friction head. The static head is the lift of 150 ft. between the pumping plant—which is practically at high tide level—and the sluicing pit at the hill proper. The pressure head at the 3½-in. nozzle is 100 lbs., and the remainder 13.5 lbs. is the amount allowed for the friction of the 1,500 ft. of 14-in. steel pipe.

On Feb. 11, Prof. C. W. Harris, with students of Washington University, made a test of the installation, the results of which are given below. To the credit of the pump, it is to be remembered that the work was done in spite of a leak in the suction pipe which allowed the needle of the vacuum gage to vary from 3 to 5 ins. The efficiency obtained (47%) is worthy of attention in that it includes everything from volt-amperes at the board to the water actually delivered at the nozzle; thus taking account of motor, exciter and pump efficiencies and also the losses in belt transmission, and by leakage from 1,500 ft. of pipe.

The plant was designed and installed by G. H. Tinker, of Caldwell Bros. The switchboard and electrical connections were designed by F. G. Simpson, of Kilborune & Clark Co. Both the above are Seattle firms.

The accompanying cut shows the stream thrown from the nozzle applied by this pump and also a nozzle supplied from the city water mains.

MEAN VALUES FROM TEST OF HAWLEY PLANT.

Actual lift from tide water to nozzle	102 ft.
Pressure at nozzle 102 lbs.	235 ft.
Loss of head by friction between pump and nozzle	26 ft.
Loss of head in suction (friction, entrance, velocity, etc.)	11 ft.
Quantity discharged (3,400 gals. per min.)	7.58 cu. ft. per sec.
Power required to lift water against nozzle pressure	185.7 HP.
Power lost in overcoming friction, etc.	22.6 HP.
Total power applied to water	208.3 HP.
Total power applied to motor	442 HP.
Efficiency of entire plant, including pipe line	47%
Efficiency of plant (deducting pipe line losses except leakage)	51%
Efficiency of pump	82.3%

The pump efficiency is figured on 91% motor, belt and journal efficiency. Pipe leakage could not be determined, but such correction, if made, would only increase the pump efficiency.

*Seattle, Washington.

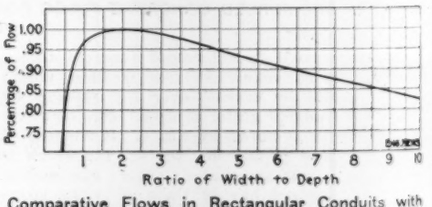
HINTS ON CONDUIT DESIGN.

By HAROLD PETTERSON.*

As is well known, the maximum velocity for any conduit which is rectangular in cross-section is obtained when the width is twice the depth. The accompanying diagram shows the rate of decrease from the maximum for other ratios of width to depth. It is evident from the diagram that the ratio of width to depth may be varied between the limits of 1½ to 1 and 3 to 1 without materially reducing the carrying capacity.

Practical considerations will often make the true economical section vary considerably from the theoretical one. For example, if a conduit is to be covered, the cost of cover will be found to increase as the square of the span; that is, as the square of the conduit width. Again, in a deep cut on hillside work, the volume of the excavation above the conduit proper will be found to increase with the square of the width. The true economical section is one which reduces the total cost of excavation and material to a minimum. In the two cases cited above, the economic ratio of width to depth will be considerably less than 2 to 1.

Of all known sections, the circle or semicircle has the least wetted perimeter for a given area of cross section, and hence, generally speaking, may be called the most economical section. Herewith are tabulated values which show how three other types of sections compare theoretically with the semicircle in economy. The trapezoidal section given is assumed to have a width at water surface equal to the sum of the two sides, and the sides to make an angle of 60° with the horizontal, which is the economical section for the trapezoid. The rectangle has a ratio of width to depth = 2 to 1. The economical V-shaped section is one whose sides



Comparative Flows in Rectangular Conduits with Varying Ratios of Width to Depth, But with Area of Cross-Section Constant.

are at right angles, and hence each make an angle of 45° with the horizontal.

COMPARISONS OF VARIOUS CONDUIT SECTIONS.

Type of section.	Hydraulic radius.	Relative area for equal capacity.	Relative construction material for equal capacity.
Semicircle	.399 $\sqrt{\text{Area}}$	1.00	1.00
Trapezoid	.38 $\sqrt{\text{Area}}$	1.023	1.08
Rectangle	.354 $\sqrt{\text{Area}}$	1.064	1.20
Triangle	.354 $\sqrt{\text{Area}}$	1.064	1.20

The diagram and the table have been found useful by the writer in designing conduit sections for the Los Angeles Aqueduct, especially in determining the approximate economical section for varying character of excavation.

*Office Engineer, Los Angeles Aqueduct, Los Angeles, Cal.

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The attention of many engineers is being directed toward the remarkable developments in the production of alloy steels, or steel containing a percentage of various materials introduced to give it special mechanical qualities. It is true, of course, that several alloy steels have been known and more or less used for a long time. Chrome steel was successfully exploited for ore stamps and similar purposes over twenty years ago. It is nearly as long since nickel steel was first applied to armor plate manufacture. Tungsten steel dates back to Mushet, who was Bessemer's distinguished rival. Manganese steel is nearly as old. In general, however, the application of all these materials has been confined to very limited fields until the last half dozen years, when the necessities of engineering work have forced the alloy steels into rapidly widening use.

In addition, the list of alloy steels has recently been largely extended, and some of these newer materials possess properties that are nothing less than phenomenal, in the light of carbon-steel possibilities. Enormously high ultimate strength and elastic limit, great ductility and extreme toughness are exhibited by them in various combinations. For example, Mr. J. K. Smith, speaking recently before the Central Railway Club, described a vanadium-steel with a tensile strength of 94,000 lbs., and a yield-point of 61,000 lbs. per sq. in., combined with an elongation of 33% on 2 ins., 61% reduction of area, and resistance to impact and stress alternation of very high order. He also described another steel having a strength of 233,000 lbs., and a yield-point of 224,000, with 11% elongation and 39% reduction of area.

The particular types of steel alloy just mentioned are produced to meet the exceptionally severe requirements of automobile service. It happens that the principal demand for the "rare" alloy steels comes from this very source. The conflict of weight and space requirements with those of strength and durability is extreme in the automobile. The same conflict has wrecked many a promising mechanical invention or at least held it short of its fullest perfection. But in the case of the automobile the restrictions of cost, which are final and prohibitive in other cases, had much less influence, so that these expensive alloys—for they are in fact high-priced—could be freely drawn upon. The high-power automobile of the present day is in no small degree made possible by these alloy steels.

The discussion of alloy steels with prime regard to their use in the automobile, is to be a leading feature of the annual convention of the American Society of Mechanical Engineers at Indianapolis this month. It is to be hoped that this will bring out and disseminate full information about the engineering properties of these materials.

Undoubtedly mechanical engineering is indebted to the bicycle industry for the introduction of ball bearings into general machine construction; and it is quite reasonable to believe that the use of alloy steels in the automobile may pave the way for their much wider use in mechanical engineering work.

Railway improvement and reconstruction has been a conspicuous feature of engineering work during the past few years, and while the railway construction work now in progress includes many important new lines and extensions, it is probable that the extensive work of improving and reconstructing existing lines in order to increase their traffic facilities and their safety and economy of operation is actually of greater importance.

These improvements are of a varied character, the principal among them being as follows: double tracking, the provision of additional sidetracks and passing sidings, the reduction of grades and curves, the shortening of distance by direct lines and cut-offs, the avoidance of congested terminals by special lines for through traffic, the reconstruction of bridges, the increase of yard and terminal facilities, and the establishment of block signals and interlocking plants.

These improvements are usually made to secure greater traffic capacity and the more economical maintenance of the line and movement of trains. There are certain cases, however, where they are made on what is termed a "General Manager's proposition"; that is, an improvement in line and grade, for example, may be desirable as giving a safer and more comfortable road for fast passenger trains (especially if in competition with other roads) although little or nothing may be gained in the way of improvement of facilities or economy in handling the traffic.

We give considerable space in this issue to a description of some typical railway improvements now in progress on two important railways, one located in the territory between Lake Michigan and the Ohio River, the other in the Pacific Northwest.

As an illustration of the amount of capital now being absorbed by railway companies in this one department of line improvements, we have compiled from the annual reports of ten leading companies the expenditure during the fiscal year ending June 30, 1906, on various classes of line improvement. The figures are given in a table herewith and show that ten important trunk lines, aggregating 53,846 miles, spent an aggregate of $43,130,000 in betterments and improvements, exclusive of extensions and new equipment.* This total includes $9,337,000 for double tracking and additional main tracks, $6,168,300 for yards and sidings, $881,200 for signals and interlocking, and $5,406,000 for revision of grades and curvature.

This average of nearly $4,000 per mile on line improvements alone in a single year represents only one of the directions in which railway companies are finding employment for additional capital. Expenditures for rolling stock and for shops to maintain it are forced upon all the companies by the huge increase in traffic; and track elevation and added terminal facilities in all large cities represents another heavy demand on the railway treasuries.

Some time ago* the question whether a steel contractor's weight estimate should include rivet heads only or the full rivets was discussed in this column. The question refers to bills rendered for work taken on a pound-price basis, when the contractor's works are not equipped with scales for weighing the finished material as shipped. We expressed the view that in the absence of a definite understanding with the purchaser, prevailing practice in the preparation of weight estimates should govern. Generally, we suggested that it would be reasonable to include the full rivet weight, as an offset to the over-run of the shape and plate steel over its listed weight per foot. Two letters, one of which appeared in our issue of March 7, while the other is printed in the correspondence columns of the present issue, indicate that this suggestion is not tenable.

The two letters in question, both of which come from men of considerable experience in the buying or acceptance of steelwork, take direct issue with our recommendation. They agree in affirming that steelwork is universally bought and paid for by shipping weight, that scales for determining shipping weights are an essential part of a steel contractor's equipment, and that one not provided with a scale is inadequately equipped, according to present commercial practice. Now, manifestly, a contractor cannot be permitted to benefit by his own insufficient equipment, that is, he cannot be allowed to secure easier or more advantageous conditions thereby than his competitors, but on the contrary all uncertainties or contingencies arising from this insufficiency of equipment must be interpreted to his disadvantage. This principle, whose validity is necessary to safe practice, yields the following conclusions:

Payment for the steel furnished without weighing because of the contractor's neglect to provide a scale according to custom, should be based on the best obtainable estimate of the actual shipping weight. In making this estimate all reasonable uncertainties are to be interpreted in favor of the buyer. Therefore, the weight will be estimated by computing the weight of shapes and plates according to their listed weights per foot, making deductions for all cuts and holes, and adding the rivets; or, since the shop-rivets fill the holes punched for them, deduction should be made only for cuts, pin-holes and field-holes, and then only the rivet-heads of the shop-rivets added. The weight estimate thus obtained is subject to no presumptive alteration, but is to be corrected only if it involves an error whose existence is quite certain and whose amount is approximately fixed.

Now it may be claimed that steel always overruns its listed weights, and that for this reason an allowance therefor should be made by adding say 1% to the weight estimated as above. But the detailed tabulation presented by Mr. Carpenter in his letter in this issue, containing a comparison of scale and estimate weights of fifty bridges, completely refutes this contention. This table shows that about as many bridges weighed less than estimate as those that weighed more than estimate; that the majority of bridges weighed within 1% of their estimate; that the maxima of over-run and under-run are about alike; and that the average of the entire fifty

*The figures referred to above are given herewith as a matter of interest. They are, however, merely approximate, and far from complete, owing to the way in which the accounts are published.

*Engineering News, Feb. 14, 1907, p. 184.

EXPENDITURES ON RAILWAY IMPROVEMENTS BY TEN COMPANIES FOR THE YEAR ENDING JUNE 30, 1906.

Railway.	Miles.	Additional main tracks.	Yards and sidings.	Signals and interlocking.	Revision of line and grade.	Total.
Union Pacific	5,664	$1,432,321	$431,055	$347,740	$164,375	$5,740,670
Atchison, Topeka & Santa Fe	8,444	1,935,700	.....	.....	3,350,000	7,456,500
Chicago & Northwestern	7,430	348,767	1,545,000	.....	.....	3,740,735
Chicago, Burlington & Quincy	8,677	44,572	1,267,385	.....	536,365	2,940,280
Chicago & Alton	970	1,654,570	59,333	66,772	145,500	2,051,900
Chicago, Rock Island & Pacific	7,218	13,073	238,847	19,256	188,139	3,514,480
Illinois Central	4,459	313,905	270,000	145,510	156,565	1,932,130
Southern	7,516	1,772,229†	1,144,725	16,319	(Col. 3)†	3,618,330
Delaware, Lackawanna & Western	445	162,476	436,874	161,260	.....	2,175,000
Lehigh Valley	1,395	381,000	.....	.....	805,000	1,570,000
Total	53,846	$9,337,670	$6,168,304	$881,246	$5,405,953	$43,132,100

†Including revision of line and grade.

bridges shows an over-run of only one-fifth of one per cent. That is, in the present problem we are not justified in assuming that the steelwork furnished without weighing had an over-run; and while the probabilities are slightly greater that it had an over-run than the opposite, this is not sufficient to justify any over-run allowance to the contractor. Mr. Carpenter's proposal to allow an over-run percentage is therefore excessively lenient to the contractor. The same conclusion makes it clear that omitting to deduct punchings, or in other words figuring the full rivets in place of only heads, on the plea that this balances the presumptive over-run, is unfair to the purchaser and is to be viewed as an attempt on the part of the contractor to pad his bill.

The venerable Charles Haynes Haswell, whose death is recorded in this issue, has for years been the most remarkable example of longevity in the engineering profession. Mr. Haswell would have celebrated his 98th birthday had he lived till the 22d of this month. That he would round out the full century was the hope and expectation of his many friends, and it is probable that he might have done this save for a recent fall, and the shock resulting therefrom. Mr. Haswell's life was most remarkable for the fact that his active work in engineering continued for nearly two score years past the age when most engineers, if they still survive, are obliged to abandon work at their profession. Mr. Haswell began his life work as an engineer in 1828, and he has done regular work in the engineering service of New York City up to almost the time of his death. Rare, indeed, is it in any walk of life, when a man retains his bodily and mental powers with advancing years so that he can not only live beyond the three score and ten mark but actually spend seventy years in active industry.

The story of Mr. Haswell's life was fully told in this journal in our issue of June 2, 1904, in connection with the celebration of his 95th birthday. In the following winter, Mr. Haswell was a prominent figure and one of the after dinner speakers at the annual dinner of the Municipal Engineers of the City of New York. His personal recollections of men who participated in the "Boston tea party" was a notable feature of the occasion.*

As recently as last fall, Mr. Haswell took part in the excursion party of the Municipal Engineers which spent a day visiting the new work of the Delaware, Lackawanna & Western R. R. at Hoboken and Newark, and tramped with the others on the tour of inspection, seeming to feel no more fatigue than men forty years younger.

THE ECONOMICS OF RAILWAY LOCATION: NEW FORMULAS FOR RAILWAY TRAIN RESISTANCE.

The work of railway revision and reconstruction which now forms such a large proportion of railway engineering work in this country has opened up an entirely new field for the exercise of the special skill of the locating engineer. The present activity in the construction of important trunk lines (greater than for many years) is also affording unusual opportunities for the locating engineer in laying out entirely new lines.

The time is easily within the memory of many comparatively young engineers when, even on important lines, the locating engineer had to concern himself little (if at all) with matters of railway operation; such matters indeed were apt to be considered rather outside the province of the engineering department. Limitations of grade and curvature, determined more or less arbitrarily and generally with cost of construction as the basic consideration, were adopted for a particular line and it was left to the locating engineer with "an eye for country" to "put it through."

We would not be understood as speaking slightingly of the earlier locating engineers; they worked, as already noted, under certain arbitrary governing conditions, and the intimate relations between location and operation were but little understood. Many of our important railway lines stand as monuments to the work of the now forgotten engineers of location, whose task it was to "either make or find a way" across prairies, deserts and mountains. And if some of these lines have required to be rebuilt or altered within recent years, it is largely because of conditions not understood and perhaps not even existing at the time of location. Where actually inferior or faulty locations were made, the responsibility in many cases rests upon the promoters who failed to realize the economic value of employing (and paying for) a high degree of skill in this particular class of engineering work. As the late A. M. Wellington picturesquely phrased it:

> There is no field of professional labor in which a limited amount of modest incompetency can set so many picks and shovels and locomotives at work to no purpose whatever.

When Mr. Wellington first published a little book on "The Economic Theory of Railway Location" in 1877 he stated in his preface that it was "an exploration of a neglected field of labor." He continued his practical and theoretical "exploration" and in 1887 brought out his more ambitious book, which has since passed through many editions without revision.

This book met with both commendation and criticism. Some engineers welcomed its bold action in claiming railway location as a field for scientific and theoretical study, while there were not wanting those who classed such ideas as absurd.

In spite of certain recognized defects and limitations, and in spite of changed conditions which have affected many factors in the problems dealt with, this book continues to be recognized as the great authority on the general theory of railway location. Mr. Wellington's analysis of the relative values of various items of railway operating expenses was a most important feature in the application of economic theory, but the modern classification of these expenses as adopted by the Interstate Commerce Commission enables the analysis to be made in much greater detail than was possible at the time the book was written. Mr. W. L. Webb, in his "Theory and Practice of Railway Construction" (1903), followed the methods of Mr. Wellington, but applied them to the more elaborate classification of the Interstate Commerce Commission.

Both Mr. Wellington and Mr. Webb have pointed out that anybody with a little knowledge of surveying and geometry, and without any knowledge of engineering in its broader sense, can lay out almost anywhere a railway which will carry trains with perfect safety and perhaps show no obtrusive defects. The losses due to defective location are not easily realized or traced, while to remedy the defects and reduce the losses is still more difficult. To paraphrase one of Mr. Wellington's statements, it may be said that the true function of the locating engineer lies: First, in comprehending the relations between topographical conditions, operating conditions, first cost and future revenue and operating expenses, and, Second, in striking a just balance between these several factors.

In the economic location of a railway specific limitations of gradient and curvature, which were once considered as the primary basis of a locating survey, are now secondary matters and to be determined only after the study of the really fundamental principles relating to operating conditions. The engineer on location must realize that he is to provide something more than a route for a line of rails on which trains can be operated. The railway is to be a means of carrying traffic and business, and the engineer must so perform his work as to provide the best and most economical means for fulfilling this purpose. We quote the following from Mr. Webb's book, already mentioned:

> The engineer must realize at the outset the nature and value of the conflicting interests which are involved in variable amount in each possible route.
>
> 1. The maximum of business must be obtained, and yet it may happen that some of the business may only be obtained by an extravagant expenditure in building the line or by building a line very expensive to operate.
>
> 2. The ruling grades should be kept low, and yet this may require a sacrifice in business obtained and also may cost more than it is worth.
>
> 3. The alinement should be made as favorable as possible; favorable alinement reduces the future operating expenses, but it may require a very large immediate outlay.
>
> 4. The total cost must be kept within the amount at which the earnings will make it a profitable investment.
>
> 5. The road must be complete, and operated, till the "normal" traffic is obtained and the road is self-supporting, without exhausting the capital obtainable by the projectors; for no matter how valuable the property may ultimately become, the projectors will lose nearly, if not quite, all they have invested if they lose control of the enterprise before it becomes a paying investment.
>
> Each new route suggested makes a new combination of the above conflicting elements. The engineer must select a route by first eliminating all lines which are manifestly impracticable and then gradually narrowing the choice to the best routes whose advantages are so nearly equal that a closer detailed comparison is necessary. The ruling grade and the details of alinement have a large influence on the operating expenses. A large part of the investigation, therefore, consists of a study of operating expenses under average normal conditions, and then a study of the effect on operating expenses of given changes in the alinement.

An important step towards the practical application of the economic theory was made a few years ago by Mr. E. H. McHenry, now Vice President of the New York, New Haven & Hartford Ry. While Chief Engineer of the Northern Pacific Ry., Mr. McHenry presented the theoretical and fundamental conditions of economic location in condensed form in the official instructions to engineers on location for that road. These were printed and discussed in our issues of April 20 and Aug. 31, 1899. The instructions were afterwards published in book form and have had a most extensive sale.

The necessity for a thorough study of economics of location applies with special force in problems relating to the improvement of existing lines to adapt them to modern conditions of traffic. In such cases the features of operating conditions (traffic, train loads, speeds, locomotive power, grades, curvature, etc.) can be much more definitely known than in the location of new lines. The economics of railway revision, as studied in relation to proposed improvements of the Union Pacific Ry., were discussed in detail by Mr. J. B. Berry (then Chief Engineer of the railway) in a paper written for the American Railway Engineering and Maintenance of Way Association in 1904 (Engineering News, April 7, 1904). In Mr. Berry's study of the economic basis of revision work, the general method of analysis formulated by Mr. Wellington and extended by Mr. Webb (as already noted) was applied to the analysis of the operating expenses of the Union Pacific Ry.

In 1904 the American Railway Engineering and Maintenance of Way Association appointed a standing committee upon the general subject of the economics of railway location, with general instructions as follows:

> To consider all questions connected with railway location, grades, lines, and improvement of grades and lines affecting the economic operation with relation to traffic, tonnage ratings, speed, density of traffic and financial considerations. The special aim of the committee should be to establish uniform methods and unit values for investigating and analyzing the relative advantages and costs of comparative routes or proposed grade reductions and line corrections.

The first report of this committee was presented at the recent annual meeting of the Association in March. It aroused much interest among the members and an abstract of the report and the discussion upon it is given elsewhere in this issue.

It will be understood that this committee is a standing committee, which will render its reports year after year, taking up different aspects of the subject in different years. In the present report chief attention has been devoted to the subject of train resistance and much space is given to the results of recent investigations. These investigations have shown that train resistance in modern high capacity cars running on heavy rails and well ballasted tracks is far below the figures assumed as correct by

*Recorded in our issue of Jan. 19, 1905, p. 80.

Wellington and earlier experimenters. For example, in the report before us, Mr. A. K. Shurtleff, of the Rock Island system, is quoted as giving the following formula for train resistance:

$$\text{Resistance, lbs. per ton} = 1 + \frac{90}{\text{av. tons wt. per car}}$$

The quantity in the denominator is the total weight of the car and load, and a table accompanying Mr. Shurtleff's letter gives the resistance per ton as ranging from 2.29 lbs. for cars weighing 70 tons loaded to 3 lbs. for 45-ton cars, 5.50 lbs. for 20-ton cars and 7 lbs. per ton for 13-ton cars.

We do not attempt to question the accuracy of the experiments by which such phenomenally low figures for train resistance are obtained, but we do question the wisdom of using such low figures or any figures below at least 5 lbs. per ton as a practical guide in railway location economics or railway tonnage rating in making up trains. In fact, Mr. Shurtleff himself, in the letter quoted in the committee's report, states that when a train is starting the resistance will be about 2 lbs. per ton higher than that given by the formula, until the train has run some distance. He says, therefore, that at least this much allowance should be made, particularly when there are apt to be frosty rails morning and evening. This agrees pretty closely with our suggestion that 5 lbs. per ton is the minimum to be considered in practical work of railway location and tonnage rating.

To reduce train mileage by increasing length and weight of trains is all very well, but when the locomotive is loaded up to a point where stalling, break-in-twos and delays to traffic occur, the economy of the reduced train mileage will exist on paper only.

The important point is that while the train resistance under ideal conditions may be as low as 3 lbs. per ton, trains must run under all sorts of conditions. A side wind or quartering wind will send train resistance momentarily away up, and so will severely cold weather, while snow, rain, sleet, bad coal or a dozen other things may cut down the locomotive hauling power.

Train resistance due to gradients and curvature is a matter of strict mathematical computation and cannot be varied. The resistance due to friction, therefore, must contain all the "factors of safety" necessary to meet the conditions of actual train operation. We feel it necessary, therefore, to add this word of caution in connection with the various statements quoted in the committee's report.

LETTERS TO THE EDITOR.

Form for Recording Notes of Preliminary Surveys for a Railway Line.

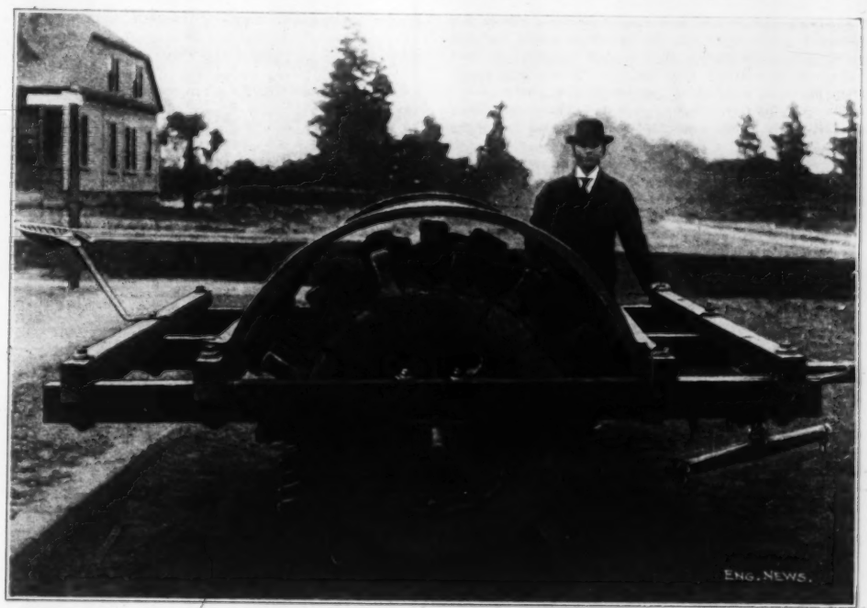
Sir: Referring to Mr. O'Connor's method of taking contours as indicated in your issue of April 25, I would say that his method is precisely the same as that used by me, but I keep my notes in a slightly different form. I enclose a specimen page taken at random from one of my railroad note books. By keeping the notes in this manner, the Resident Engineer and the Draftsman have immediately before them all the data connected with the station shown on the same page, both as to reference points, topography, bench marks, elevations, grades, alinement and deflection, as well as end area, average end area, cubic yards cut and cubic yards fill.

Respectfully, Henry M. Payne,
Gen. Supt. and Chief Engr.,
The Mingo Block Coal Company.

Williamson, W. Va., April 27, 1907.

Bituminized Dirt Roads at Santa Monica, Cal.

Sir: In your issue of April 4, 1907, there is an article on "The Asphaltic-Oiled and Tamper-Roller Compressed Dirt Roads of Santa Monica, Cal." The specifications given there do not represent the best or latest methods of constructing these roads, as several important changes in procedure have been made, with the effect that the work is facilitated, and the final result improved.

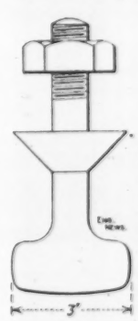


LATEST TYPE OF ROAD TAMPING ROLLER.

Bituminized or asphaltized-earth roads, as these should be called, were put in at Beverly, Cal., under the supervision of the writer. Messrs. S. Hutton & Son, of Santa Monica and Los Angeles (by whose efforts chiefly the process has been brought to its present state of perfection) acted as contractors. The initial specifications were similar to, though not identical with, the Santa Monica specifications, as given in your article. In one or two instances a tendency of the surface of the road to buckle or blister was noticed, soon after the road had been opened for traffic. These places were ripped up with a plow to re-tamp, when it was found that the upper layer had not formed a good bond with the foundation layer. An experimental section was then put in. The road was first plowed and pulverized in the usual way, after having been put to established grade. Then the oil was applied as follows: Two-thirds the total amount, or 2 gals. per sq. yd. of surface, was sprinkled evenly over the surface, each oiling being followed by a thorough cultivation of the upper 6 ins. of the road surface, to insure a complete mixing; then the entire roadway was plowed 6 ins. deep; then, omitting the first tamping, the balance of the oil, or 1 gal. per sq. yd. was applied and thoroughly cultivated in; then the tamper was brought on and the road tamped solid to the surface. The result was the finest piece of road that has so far been built. No tendency to buckle, or blister can be noticed, and the entire surface is as smooth and almost as hard as a first-class asphalt pavement.

The thorough cultivation of the oil into the soil is a most important factor in the construction of these roads. A heavy drag cultivator is kept following the oil tanks as they distribute the oil, and the cultivator is passed through ten or a dozen times in order to insure that perfect mixture without which there cannot be the best results.

Another important change is that the water is not applied until all the oil has been distributed. The dry earth takes the oil more readily than does the damp, particularly if it be of a clayey nature. The water is first applied just prior to the tamping, in which operation alone is it necessary. The function of the water is to assist in packing the earth under the tamper, and, to a certain extent to hinder the material clogging the teeth. No more water should be used than is necessary to assist packing, as the road does not attain its best state until practically all of this moisture has evaporated.



Some important detail changes have also been made in the roller itself. The tendency is towards increased weight, the latest roller weighing 5,600 lbs. The roller is set with 182 teeth. This roller is built up of 14 instead of 18 sectors, thus insuring a heavier blow from the increased fall. The teeth are set staggering, so that every part of the roadway receives equal tamping. The form of the tooth has also been modified, as per accompanying sketch, this makes a lighter draft roller, and also one that can be run equally well backward, or forward. These roads were subjected to a very severe test as shortly after they were put in, and while still green, a very heavy rain storm washed large quantities of earth, sand and rocks, varying from small pebbles to stones as large

Sta.	Align.	Deflect.	Elev.	Grade	Refs. & B.M's.	L	C	R	End Areas	Av. End Ar.	Cu. Yds. Cut	Cu. Yds. Fill.
229+00	S.35 54' E.		668.0	669.00		C 7.1 30.1 0.0 20.8 F 0.5 20.0	F1.0	F1.3 2.0 F13.4 7.4 F17.0 27.0 F21.3 42.0	C 7.81 F 113.59	C 3.91 F 188.39	14.48	697.74
228+00			667.2	668.84	Road Public P.T. ELK BRANCH	0.0 23.0 F 1.4 21.4	F1.6	F 10.1 11.0 F 19.9 34.0 F 20.1 40.2	F 263.19	F 317.30		1175.2
+27.2	P.T.	16°12'										
227+00		15°22'	665.4	668.69		F 1.3 25.0 0.0 18.2	F3.3	F 20.4 25.0 F 14.3 45.3	F 371.41	F 312.23		1156.4
226+00		12°22'	661.1	668.54		0.0 23.0 0.0 16.2 F 1.2 9.6	F7.4	F 20.4 21.4 F 22.6 43.9	F 253.06	F 240.89		892.19
225+00		9°22'	659.6	668.39	P.I.	0.0 23.0 0.0 18.4 F 0.7 13.4	F8.8	F 11.4 3.0 F 12.8 11.4 F 7.5 16.0 F 7.3 21.0	F 228.72	F 160.55		594.63
224+00		6°22'	662.5	668.23		0.0 23.0 0.0 16.4 F 0.7 13.0	F5.7	F 3.0 14.3	F 92.37	C 2.64 F 90.91	9.80	336.70
223+00		3°22'	664.7	668.08		C 0.8 34.8 0.0 10.8 F 0.8 6.0 F 3.4 4.9	F3.4	F 4.6 7.9 F 4.8 17.9	C 5.28 F 89.45	C 9.50 F 62.80	35.20	232.20

ENG. NEWS.

FORM FOR RECORDING NOTES OF A PRELIMINARY RAILROAD SURVEY.

as an orange, down the gutters, depositing it about 2 ft. thick on the lower roadway. Except for a few spots where the gutter was hardly completed, no damage was done, and the roadway after being cleaned off with scrapers, is as good as ever.

Yours very truly, Ernest H. Wilcox.

Bryson Block, Los Angeles, Cal., April 19, 1907.

Deductions for Punchings and Shearings in Structural Steelwork; Overrun of Shape Steel.

Sir: Referring to your editorial in issue of Engineering News of Feb. 14, 1907, on the basis for determining weight of structural steel work to be paid for at a pound price, when material can not be weighed, it occurs to the writer that the basis upon which the contractor referred to in the editorial made his bill [namely, weights calculated from the weights per foot of the various sections used as given in the mill handbooks, plus the weights of the rivets used, without deduction for the rivet holes] was not the logical one, and that such a basis would be slightly unfair to the purchaser.

It appears to be a fact that nearly all structural shops of any pretensions to size and standing are supplied with scales for weighing the material fabricated, and payment for work fabricated at such shops is universally based upon scale weight of finished material. First-class specifications call for these scale weights to be checked by weights estimated from the detail drawings, and set a limit for the allowable variation of scale weights from these estimated weights, generally 1½% to 2%, and state that any excess over the allowed variation shall not be paid for by the purchaser. This gives a check on the scales and on the material used in the work, and is, therefore, a very proper safeguard for the purchaser. The writer believes the general practice to be as described above, and that the contractor who does not possess scales for weighing his finished material should be considered as lacking in proper equipment, and that he should, especially when bidding in competition with fully equipped contractors, expect to comply as closely as possible with the general practice in determining weight of material for payment. Now, the scale weight gives the actual weight, assuming the scales to be correct, and the purchaser pays for just what he gets, as he should. Therefore, in case of no scales available, the weight should be an estimate of what the scale weight would be. This could not possibly be assumed to include the material removed from rivet holes.

But, you may say, the scale weight usually overruns the estimated weight. It would appear that, on the average, this is true; but that the average overrun is very small, and less than the weight of the material removed from the rivet holes. In order to get a determination of the average variation of scale and estimated weights, the writer took these weights for fifty railroad bridges, selected at random from among the great number for which he has such data available, and added them together, with the following results:

WEIGHT OF 50 BRIDGES, FABRICATED BY SEVEN DIFFERENT CONTRACTORS.

Scale	15,313,050	lbs.
Estimate	15,279,555	"
Excess scale over estimate	33,495	"

Or 0.22%.

The estimates were all made in this office, on a uniform basis, namely, deducting all cuts of shapes and plates and all field holes and pin holes, etc., and for shop rivets adding the rivet-heads only, for the purpose of getting the shipping weight as accurately as possible. Of course no allowance for overrun of weights per foot of plates and shapes is included in the estimate, so that such overrun should appear in the difference between the scale and estimate weights.

For 24 of these bridges the scale weights underran the estimate weights, with a maximum of 2.90%, and for 25 bridges the scale weights overran the estimate weights, with a maximum of 4.00% (this maximum is abnormal); for 32 bridges the variation did not exceed 1.00% either way. The weight of each bridge, the differences, and the percentages of variation are given on attached sheet, and you may think it worth while to publish same. [See table herewith.—ED.]

The weight of the punchings from rivet holes will probably average about 2% of the finished weight; so that it may be said to be to the disadvantage of the purchaser by a matter of between 1% and 2%, on the average, to have the weight estimated on the basis assumed by your contractor.

The writer thinks that the proper basis for determining the weight of the material in the case in mind is to estimate the weight of the finished material from the detail drawings, using the weights for rolled sections as given in the handbooks of the manufacturing concerns, and making allowances for all open holes, cuts, rivet heads and the like, and then to the weight thus determined add an allowance for overrun of weight in rolling. For this allowance 1% would seem to be liberal to the contractor as representing the average overrun. This basis, with an allowance of 1% for overrun, would seem to be entirely fair to the contractor, not unfavorable to the purchaser by any appreciable amount, and to represent the proper method of approximation to the usual basis of scale weight.

Yours truly,

A. W. Carpenter,

Engineer of Structures, N. Y. C. & H. R. R. R.

Grand Central Palace, New York City, April 15, 1907.

COMPARISON OF WEIGHTS BY ESTIMATE AND BY WEIGHING SCALES, FOR FIFTY RAILWAY BRIDGES.

Contractor.	Est. Wt. lbs.	Scale Wt. lbs.	Difference. lbs.	Difference. lbs.	% Diff.
A	36,452	36,938	+486	.....	+1.33%
B	25,956	25,689	.....	−267	−1.02%
A	777,497	781,815	+4,318	.....	+0.56
A	1,049,548	1,039,081	.....	−10,467	−1.0
A	70,838	69,903	.....	−935	−1.3
C	204,258	203,505	.....	−753	....
A	199,172	198,839	.....	−333	....
D	92,644	92,712	+68	.....	+0.007
A	1,340,378	1,346,170	+5,792	.....	....
A	784,927	805,110	+20,183	.....	....
A	154,891	154,970	+79	.....	+0.05
A	284,355	283,805	.....	−550	−0.55
A	139,056	138,290	.....	−766	−0.55
C	70,060	70,510	+450	.....	+0.64
A	333,063	331,275	.....	−1,788	−0.54
A	110,245	112,990	+2,745	.....	+2.50
B	366,716	367,800	+1,084	.....	+0.30
A	14,264	14,540	+276	.....	+1.95
C	187,361	186,605	.....	−756	−0.40
B	147,651	147,873	+222	.....	+0.15
B	150,395	148,006	.....	−2,389	−1.67
C	108,307	108,285	.....	−22	−0.02
B	99,450	99,160	.....	−290	−0.30
C	86,444	85,625	.....	−819	−0.95
A	627,266	623,895	.....	−3,371	−0.53
A	2,565,317	2,586,074	+20,757	.....	+0.81
A	159,154	161,139	+1,985	.....	+1.25
C	228,364	228,880	+516	.....	+0.23
A	47,079	47,243	+164	.....	+0.35
C	488,235	477,890	.....	−10,345	−2.13%
E	83,269	82,377	.....	−892	−1.08
B	69,431	72,200*	+2,769	.....	+4.00*
A	26,383	26,458	+75	.....	+0.30
A	73,941	74,164	+223	.....	+0.30
A	75,110	75,488	+378	.....	+0.50
A	73,941	74,203	+262	.....	+0.35
D	420,947	427,921	+6,974	.....	+1.66
C	15,678	15,551	.....	−127	−0.81
A	23,221	22,898	.....	−323	−1.40
E	253,638	260,600	+6,962	.....	+2.75
E	40,429	39,260	.....	−1,169	−2.90
E	40,483	40,440	.....	−43	−0.10
D	420,008	426,874	+6,866	.....	+1.64
D	43,248	44,114	+866	.....	+2.00
B	326,258	324,150	.....	−2,108	−0.65
F	184,596	186,800	+2,204	.....	+1.20
G	428,204	425,066	.....	−3,138	−0.70
G	317,394	314,508	.....	−2,886	−0.91
A	353,172	356,419	+3,247	.....	+0.92%
G	1,060,861	1,048,942	.....	−11,919	−1.12%
Total ... 50 bridges..	15,279,555	15,313,050	+89,951 −56,456	−56,456	
		Net overrun	33,495		+0.22%

*Abnormal because contractor used heavier material than estimated in some members.

An Engineering Dinner Specification.

Sir: Having noticed in some of your former issues certain quaint menus of engineering festivities, I take the liberty of enclosing one of a supper given by one department of the engineering force on the Barge Canal to another.

Yours truly, A. B.

Albany, N. Y., May 7, 1907.

Disorder No. 23. May 6, 1907.

DIRECTIONS TO LOCK TENDERS FOR MAKING EMBANKMENTS AND BACKFILLS IN VOIDS OF DAM FAMILY.

First—When a little fill is required, treat it by ordinary methods—a ham sandwich will suffice.

Second—When big fills are to be made in big hollows the method below should be followed:

GRUB, then the alimentary canal and other cavities shall be washed with MARTINI, immediately following which a thin layer of CLAMS shall be spread and then sprinkled with SOUP. This shall be considered a satisfactory foundation into which shall be driven a STEAK properly centered. Next a rich puddle of POTATOES and ONIONS sufficient to stop all leakage shall be placed in a workmanlike manner. After ramming or otherwise thoroughly compacting the mass to the satisfaction of the engineer in charge, the whole shall be copiously wetted down with BEER. If deemed best the fill may be strengthened at this point by a first class SALAD deposited wet. The finished structure shall be topped off with a CHEESE and CRACKER lining of approved quality.

COFFEE (dam black) may surround the finished fill. Before final acceptance of the work each section shall be subjected to the heat and smoke resulting from the oxidation to incipient fusion of a properly proportioned mixture of oxygen and a Peter Schuyler CIGAR.

Notes and Queries.

An error appeared in our issue of May 2, in the report of the fire in the noted Homestake mine at "Lead, Colo." As most of our readers are doubtless aware, the mine is located at Lead, South Dakota. Mr. Bruce C. Yates, Assoc. M. Am. Soc. C. E., who has for ten years been associated with the Homestake Mining Co., and is now Principal Assistant Engineer, advises us that the normal flow of Whitewood Creek, which has been turned into the burning mine, is not more than 200 cu. ft. per min., while about 1,500 cu. ft. per min. are now pouring into the workings. The greater portion of that amount comes from the regular water supply ordinarily used in treating the ore and for domestic purposes.

THE BRONX PARK DERAILMENT ON THE NEW YORK CENTRAL: REPORT OF THE STATE RAILROAD COMMISSION.

On Feb. 16, 1907, an alarming derailment occurred on the Harlem division of the New York Central & Hudson River R. R., within the limits of the new Electric Zone. A passenger train, drawn by two of the railway's new 2,000 HP electric locomotives, was derailed on a 3° curve, resulting in the death of nearly twenty-five passengers. At that time the frequency of derailments on American railways had almost reached the stage where this type of train accident might be called epidemic. Popular interest in the Bronx Park derailment was greatly increased by the fact that it was an electric train that left the track, and in consequence much public criticism was directed against the electric locomotives, the conduct of the electric equipment work, and every person concerned with either subject.

The accident possessed also a technical interest of perhaps equal intensity; this was a quite legitimate interest, based on the following conditions: (1) the curvature and superelevation at the point of derailment were quite normal for high-speed track; (2) no evidence was at hand to point to an obstruction on the track as the cause; (3) the track was of standard construction for first-class track carrying heavy and high-speed traffic; (4) a dense traffic, much of it high-speed, passes over this track; (5) the track was subject to as good inspection and maintenance work as is put on any other part of the New York Central lines; (6) the character of the derailment suggested yielding of the outer rail to an outward pressure sufficient to shear the spikes; (7) the curve rail-pressure of the new electric locomotives as compared with that of a representative steam locomotive was not known, so that it appeared possible that inherently excessive rail-pressure might be responsible; (8) the general obscure state of the science of curve-mechanics of railway vehicles, which makes the condition noted under (7) highly speculative.

We have already given (March 7, 1907, p. 275) the substance of the findings of the coroner who held the inquest on the death of those killed in the accident, and later (March 14, pp. 296-299) an account of the conditions surrounding the derailment, including a tabulated statement of rail-pressures of the New York Central type of electric locomotive in comparison with those produced by an equivalent Atlantic locomotive, as calculated by the engineering department of the railway company. We have now to record the completion of the report of the Board of Railroad Commissioners of the State of New York, which also investigated the accident.

The Railroad Commission's report, dated May 3, adds nothing to the facts or inferences already made public. It dismisses three possible assumptions of cause, namely: (1) obstacle on track, (2) broken parts of equipment, and (3) defects inherent in engines, as not being indicated or rendered probable by the evidence brought forward. It finds the responsible cause in the character of the track combined with high speed of the wrecked train. There was a report of "very rough track" at the curve where the derailment occurred, sent in by an engine-runner who took a train over the same track about eight hours before the derailment, as already noted in our accounts concerning the wreck. Many persons have taken the view that this report must have been founded on error, because no other trains during the day made a similar report and because a track foreman who inspected the curve an hour before the accident, on an order resulting from the report mentioned, found nothing wrong. But the Commission concludes that the report was very certainly based on a bad, quite unusual, jolt which the morning train felt at this point, and believes that succeeding trains during the day must have further aggravated the roughness or abnormal condition which existed there. As to speed, it concludes that the train which was derailed had a speed of approximately 65 miles per hr. at the time of derailment; the schedule speed for this section was 57.6 miles per hr. This conclusion as to cause is clearly stated in the

first paragraph of the Commission's findings, which findings are as follows:

FINDINGS.

The Board finds that the accident was caused by a condition of weak track which was discovered and reported by the engineer of train 5X which left the Grand Central Station on the morning of Feb. 16 at 9.03 a. m. Also that this bad spot became worse by reason of the pounding it received from numerous passing engines, holding, however, until subjected to the unusual and abnormal pressure exerted by the impact of the two powerful electric locomotives running at a very high rate of speed striking it in quick succession, shearing the spikes and causing the rail to spread. The accident, therefore, was the result of a track condition, plus speed, plus again the neglect to locate and remedy conditions that had been reported on the morning of the accident.

The Board believes that it was the duty imposed upon the Division Superintendent of the Harlem Division, on receipt of the telegram referred to, to have warned the engineer and motorman of each succeeding train called by schedule to go over that division of the reported condition on track 3, and that a failure so to do was a clear violation of such duty and that if that duty had been performed it might have prevented the accident.

The Board is further of the opinion that on the day of the accident in question no trains should have been allowed to run over the Harlem Division on track 3 even at their schedule rate until the Track Supervisor on that division had reported affirmatively to the Superintendent or the General Manager even, that the track in question was right in every respect. The testimony adduced by the Board fails to show that any such affirmative report was made, and the officials of the railroad when given an opportunity to offer evidence on this subject likewise failed to produce any testimony to that effect.

More important, however, than these conclusions are the succeeding paragraphs of the Commission's report, containing its recommendations for changes and improvements to be made by the railway company in construction or method. Special attention is due the recommendations headed (3) to (8) inclusive, as they concern administrative procedure and criticize methods that are practically universal in American railway operation. Recommendation (5), which advocates a clear separation of direction and responsibility of the operating department from those of departments concerned with construction work, is especially of interest to engineers. Recommendation (1), concerning shouldered tie-plates, will clearly be helpful against excessive spike-shear due to a low coefficient of friction between rail and tie-plate. A similar object should be kept in view in the design of steel ties or other substitutes for the wooden tie, as suggested by the derailment at Mineral Point, Pa., on the Pennsylvania R. R., reported in our issue of March 7, 1907, p. 264.

RECOMMENDATIONS.

The Board recommends:

(1) That the New York Central and Hudson River Railroad Co. cause all tangents and curves on the main line tracks in the Electric Zone to be equipped with what is known as the "shoulder tie-plate," constructed with a shoulder on the outside of each rail, with four spikes, two on either side of each rail, on each tie. The necessity of immediate action on the subject of this recommendation was deemed of such importance that the suggestion thereof made by the Board to the road prior to this report is at present being complied with.

(2) That the company cause all curves in the Electric Zone to be maintained at a superelevation not less than the present standard requirements.

(3) That a careful, persistent and comprehensive observation of all conditions—track, roadbed, cars and engines—be made wherever electricity is being used, and that a record of such observations be kept in the office of the company, and that at stated periods, not less than four times a year, the result of these observations be filed with the Board of Railroad Commissioners. While the Board has no criticism to offer as to the comprehensiveness and thoroughness of the preparation for the electrification under the statute, it believes that there are many elements necessary to be known before electrification can be considered as solving all problems presented, and that there are still elements and conditions which may be only known by experiments and cannot be arrived at conclusively from scientific deductions.

(4) That there should be the same degree of intelligence in track maintenance as in track construction, and that it should somewhere appear, always affirmatively, in the records of the company and the responsibility located upon some particular officer, that the track and roadbed are fit for given trains of given weight and speed. * * *

(5) That some method should be devised whereby the line of responsibility between the construction and operating departments shall be kept clear and distinct. The Operating Department should not assimilate the work of the Construction Department. Wherever there has been a work of construction, and it is complete and the Operating Department is about to take it over, it should only be so done after the work of construction is entirely complete and the Operating Department accepts it as such. When that point has been arrived at and the construction is satisfactory to either the Board of Directors or the Operating Department, there should be as clear a transfer, evidenced by a written record, as a transfer of title evidenced by a recorded deed.

(6) That it would be to the best interests of the public and the railroad company if the rules of the company required a consultation between the persons charged with maintenance-of-way of a particular division for instance, and the person charged with making up the train schedule, before such schedule were put in effect. In other words, while the head of the railroad company may give a direction which if carried out would justify the assumption that track and roadbed would stand a speed of a certain number of miles per hour by a fast train, we believe that safety can only be assured and responsibility located, provided that before such new or fast schedule goes into effect the person charged with the responsibility for the maintenance and upkeep of the track over which the train is to go shall certify affirmatively to those in charge of the schedule that that particular track will stand the added particular traffic.

(7) That no one should be charged with the responsibility of construction or maintenance, where the nonperformance of a duty may jeopardize human life, who is unable to express the result of his observations intelligently.

(8) That rules should be so made in the carrying out of administrative duties as to make impossible the shifting of a responsibility from one person charged with it to another. * * *

The enormous growth of freight and passenger traffic has made it, the Board fully understands, very difficult for those in railway management to develop and amplify their administration in keeping with this enormous demand of traffic. From information submitted to the Board, it is satisfied that the development of business has outstripped the development of administration. This does not mean that there has not been a proper division and subdivision among administrative officials. The Board appreciates the difficulty of obtaining men of proper training and capacity to bear the responsibility of executive and administrative duties in railway management. It believes, however, that it is wiser to learn the lesson before than after the accident, by so clearly defining duties and responsibilities that subordinates shall be compelled to report to superiors that things are right and take their responsibility for their being wrong, rather than tax their ingenuity in explaining how things might have been different. * * *

(9) That the company employ track walkers on each section in the Electric Zone at all hours of the day and night.

(10) That each electric locomotive and each electric motor car operated in the Electric Zone be equipped with fire extinguishers.

FIG. 1. A TEST PIT IN THE CRACKED ADOBE SUBSOIL, NEAR THE COLORADO RIVER BREAK.

FIG. 2. ANOTHER TEST PIT IN CRACKED ADOBE SOIL.

Fig. 3. Typical Surface of Cracked Adobe Soil, Near the Colorado River Break.

THE CONSTRUCTION OF THE LEVEE BELOW THE RECENT COLORADO RIVER BREAK.

By C. W. OZIAS.*

As has been stated in these columns, the break in the bank of the Colorado River has been closed in such a manner as to be considered permanent,† but permanent control of the river depends largely upon the levee system, the larger part of which lies below the recent break. Soon after the closure work was started, late in December, 1906, the reconstruction of the remaining part of the old levee and its extension to the south was begun with a large force. It was necessary to do this work at once, as the river is liable to floods at any time during the winter or spring, and in case of a flood of more than mean height the break might have been repeated around the end of the levee. The annual overflow occurs in June and floods the entire lower country, making it necessary to complete the levee to a point of safety by that time.

The soil of the lower valley is sedimentary in character. Its composition and nature are variable, owing to its having been brought down by the tributaries of the Colorado from places of differently composed soils. The soil is in general very light and is easily carried by a slow velocity of water.

The most troublesome of these soils, in levee building, is the Salt River adobe. It has been deposited in layers at different times over nearly all of the lower valley. These layers have been

*Assistant Engineer, U. S. Reclamation Service, Yuma, Ariz.; loaned to the California Development Co. to assist in constructing the levee.

†See Engineering News, Feb. 21, 1907.

covered by the next flood, from some other tributary, with sand, loam or light silt. Consequently the subsoil is composed of layers more or less definite of the soils from the different tributaries of the Colorado. The Salt River adobe is a very heavy dark brown to black clay loam, sticky and plastic. As a rule, this soil occurs along the sloughs and old river beds, where water may often be found after the river has fallen.

When the water subsides after it has been deposited and the surface is exposed to the hot sun, large cracks, two to six inches wide, cut the surface in every direction, often extending into the soil three or four feet. These cracks divide the soil into blocks one to two feet in diameter.

When the land is again submerged the soil does not swell up again and close the cracks, as might be expected. Where these layers of adobe are covered with material of different character, before being exposed to the sun, and are then subject to heat, they dry out and crack, leaving large voids between the blocks, as shown by the accompanying views. These blocks harden to such an extent that some exertion is required to cut them into shavings with a knife. They yield under pressure only after several hours of immersion in water. It is the voids between these blocks that have given trouble in levee construction and maintenance.

For about two miles below the recent break the levee is located on high land near the river. At this point the Old Paradones River, one of the "outflowing tributaries" of the Colorado, leads to the southwest, and away from the Colorado. The Paradones has in the last few years entirely silted up, and what used to be its channel is now higher than the surrounding surface. In order to get high ground the levee was located near the old channel, where the soil conditions were as good as could be selected. The alinement was made as smooth as possible, the maximum curvature in the main levee being two degrees. The grade line was laid 6 ft. above high water at the upper end and 5 ft. above high water at the lower end, where the levee is farther from the river, and 2 ft. above the grade line of the levee on the opposite side of the river. The levee is built with a 10-ft. top and with a 3 to 1 slope on both sides.

In the construction of the levee the soil conditions below the surface are thoroughly investigated to a depth of 8 to 10 ft. by means of test pits at intervals of 200 ft. In this manner was determined the depth to which it was necessary to excavate the muck ditch, under the base of the levee, before building the levee proper. In all cases the excavation was put below all cracked adobe and deep enough to remove all buried driftwood and vegetable matter.

In the reconstruction of the 1½ miles of old levee below the break to Station 114 a muck ditch was constructed under the land slope of the levee. The levee was cut down vertically from the land side of the top and excavation carried down into the original ground, with a width of 6 to 10 ft. and with depth enough to thoroughly remove all bad material. The material removed was cut and mixed with the better material to such an extent that it was in good condition for backfilling. The excavation was backfilled with Fresno scrapers and well compacted by the mules. The levee was built up full to a 3 to 1 slope.

In the construction of the new levee below Station 114 the muck ditch was excavated with a 6-ft. base and 2½ to 1 slopes. The first mile of excavation was of a depth such that the top width occupied almost and in some places the entire base of the levee. This necessitated handling twice the material from the excavation, as after it was removed and thoroughly cut up and mixed it was nearly all suitable for backfilling. The soil below the excavation was inspected and the bottom and sides plowed before refilling. In the refilling the material was carefully inspected and cleaned of all roots and trash so as to form as nearly as possible a watertight core. Puddling was not considered advisable, since it was thought that there was danger of the material drying out and cracking, as it is not likely to do when put in with the natural moisture. It has been found that the material is damp enough to become very compact and firm in the levee.

Where the muck ditch was of smaller proportions and occupied only a little more than half the base of the levee, it was placed with one land slope stake of the excavation on the original toe of the levee and extended inward the width of the excavation. Where the width was less than half the base of the levee it was placed with the water slope stake on the center line of the levee so that *in no case is the muck ditch under the extreme land toe of the levee.*

FIG. 4. 10-FT. MUCK DITCH READY TO BE REFILLED; STATION 180, COLORADO RIVER LEVEE.

FIG. 5. COLORADO RIVER LEVEE RECONSTRUCTION, STATION 100, NORTH.

was the construction used in the part of the levee where the soil conditions were good and the muck ditch was needed only as a precaution against underground openings caused by decayed vegetable matter. The minimum depth of excavation used was 3 ft., and this ruled on less than one-fourth of the levee under construction. In this case the material excavated from the muck ditch was placed directly into the levee, on the part of the base not occupied by the muck ditch. The base was grubbed and plowed.

In view of the fact that the ground surface slopes 3 ft. per mile, in the direction of the levee, and that there is danger of a channel forming near the water side of the levee, the borrow pits were placed on the land side, with a 40-ft. embankment berm and a depth of 4 ft. on the inside and a slope of 1 in 50 to the back side. At intervals of 400 to 500 ft., checks 17½ ft. wide were left across the borrow pit.

While it is acknowledged that the borrow pit on the land side is a source of weakness from danger of a blow out it was considered undesirable, with the existing slope, to place any invitation whatever to a channel near the levee, on the water side, and with the muck ditch carried below all doubtful material it was considered that the land side borrow pit was the lesser of the two evils.

The levee was constructed as described to Station 365 (six miles below the recent break). Upon recommendation of the Board of Consulting Engineers for the U. S. Reclamation Service, a change in the general design was then made. The board considered the land side borrow pit dangerous, and what is known as the "checker board" borrow pit was recommended and is be-

FIG. 6. ON THE UPPER END OF THE LEVEE, LOOKING NORTH.

FIG. 7. ON THE LOWER END OF THE LEVEE, LOOKING TOWARD RIVER.

FIGS. 6 AND 7. TAKING DIRT FROM THE BORROW PITS WITH FRESNO SCRAPERS.
(Fig. 6 represents work on the old and Fig. 7 on the new, or Checker Board system.)

ing used south of Station 365. The borrow pit is on the river side of the levee, with a 40-ft. embankment berm. Each pit measures 100 ft. long along the levee, and between each pit is a cross berm 100 ft. wide, with the brush and trees undisturbed to the toe of the levee. The borrow pit extends back a sufficient distance to get material to build the two stations of levee in front of the pit and in front of half the adjacent cross berms. The cross berms and the undisturbed vegetation are intended to cut off the current sufficiently to prevent the formation of a channel.

Upon the same recommendation the muck ditch has been changed to the water side of the center line of the levee, in consideration of the fact that the muck ditch is built to cut off all passage of water under the levee, and it was thought desirable to cut it off at the entrance rather than at the exit. Advocates of the land side muck ditch maintain that the dead water in the base of the levee may be beneficial to it in assisting efficient compression and silting up of all openings. It has been found that the hard adobe will press together after a number of hours of immersion. The advocates of the water side muck ditch maintain that the buoyant effect of the water which may exist under a part of the levee with the land side muck ditch is especially undesirable.

Throughout the construction of the levee extreme care has been used in regard to the condition of the material going into the embankment. In some places very coarse adobe is encountered in the borrow pits and the large chunks are not suitable for the levee. Hand picking of the clods and harrowing the material as put into the levee has been found to make very satisfactory work in these cases.

The work is being done by contract, and the four-horse Fresno scraper now so popular in the southwest is being used for the entire work. The new design of borrow pit increases slightly the cost of construction, on account of the increased length of haul.

The construction has been pushed as rapidly as possible. During the month of February, 270,000 cu. yds. were moved. At present six hundred head of stock are employed and 7,000 cu. yds. are being moved per day. Indian labor is now used almost entirely.

The work contains 720,000 cu. yds. to Station 581. On April 4, 100,000 cu. yds. remained to be moved to complete the levee to this point, where it is intended to stop the work this year. At this point the surface of the ground is lower than the channel opposite, leading to Salton Basin, so there is no danger of the river cutting around the end of the levee and getting back into the old stray channel.

A railroad track is being laid on the levee as rapidly as it is completed. It is ballasted with 1 ft. of gravel below the base of the rail. Gravel is being dumped from side-dump cars and spread 1 ft. deep over the slopes of the levee. It is spread by means of a machine built especially for this purpose. The machine is a flat car, fitted with wings which can be adjusted to the slope of the levee, and pushes the gravel down the slope as it is pulled along by the engine.

A telephone line is being built along the land side of the levee, for use in patroling the levee during high water.

A SERIOUS WRECK took place on May 11 at Honda, Cal., on the line of the Southern Pacific, near Santa Barbara. Latest press reports place the dead at 35 and the injured as many more. From available reports the disaster was due to a defective switch; the coroner's jury, which held the inquest at Honda, returned a verdict to the effect that the railroad company was criminally negligent and that the wreck was due to "defective equipment"; a second jury, sitting at Santa Barbara later, concluded that it was unable to assign a cause from information which it was able to obtain from railroad officials.

RAILROAD TRAIN ACCIDENTS in the quarter ending Dec. 31 last caused 474 deaths and injured 4,940 persons. Accidents of all other kinds, including those sustained by employees at work and by passengers in getting on and off cars bring up the total casualties for the quarter to 1,430 killed and 19,514 injured. The number of passengers killed in train accidents was higher than in any previous quarter save two since the Interstate Commerce Commission began its record of accident statistics. Of the 180 passengers killed in the quarter, 143 were killed in three accidents, viz., the Atlantic City drawbridge wreck on the Pennsylvania, the rear collision at Terra Cotta, D. C., and the head collision at Woodville, Ind., both on the Baltimore & Ohio.

The total number of collisions in the quarter was 2,226 and the derailments numbered 1,739. Tht property loss caused was $3,100,000.

A CROWDED SUBURBAN TRAIN on the Chicago, Burlington & Quincy Ry. left the tracks in the outskirts of Chicago on May 9, killing one passenger and injuring 60 others. Press dispatches state that the engine is believed to have struck a defective rail. Laborers had been working at the track at that point just prior to the passing of the train.

THE BALTIMORE PIER COLLAPSE has been investigated by a coroner's jury, and a verdict was reported on May 13. The accident is charged to improper construction of the pile foundation, and the responsibility is laid upon the Baltimore & Ohio R. R., for whom the pier was being constructed. However, no charge of criminal negligence is made against either the railroad company or its engineers. The evidence brought out in the inquest showed that the outer end of the pier moved laterally during the week preceding the collapse, a total distance of between two and three feet, but those in charge of the work were in no apprehension of danger.

THE S. S. "POITOU," of the Transports Maritimes Line, was wrecked on May 7 off the coast of Uruguay, near San Jose Ignacio, a small, rocky promontory about 150 miles from Montevideo. Latest press dispatches say that the vessel carried about 160 passengers, of whom all but 13 were rescued.

A NEW LAKE PASSENGER STEAMER, nearing completion at the yards of the Detroit Shipbuilding Co., was destroyed by fire just before daylight on May 13. A press dispatch states:

The "City of Cleveland" was intended to be the finest side-wheel steamer on fresh water, and her interior woodwork, all of which is destroyed, was unusually beautiful and lavish. Her whole cost was intended to be $1,250,000.

It is doubtless the presence of so much interior woodwork of inflammable finish that accounts for the rapid destruction of the vessel. The fire is another object-lesson—fortunately unattended with loss of life—of the inherent danger of the present fire trap construction of passenger vessels on inland waters.

A FIRE IN THE TENARES COPPER MINES at Velardena, State of Durango, Mexico, which started on May 10, is believed to have cost 90 lives. Working in the mine at the time the fire started were 107 men; of this number but 17 escaped, and the 35 bodies so far recovered are charred beyond recognition. The portion of the workings in which the fire started is very dry, and it is believed that carelessness with a cigarette started a blaze which quickly spread to adjacent timbering and gained great headway before being discovered. The mine, one of a group of large copper producers in northern Mexico, is owned by the Guggenheim interests.

LARGE RAIL ORDERS were placed by the Pennsylvania lines, the Union Pacific and Southern Pacific lines and the Illinois Central R. R. during the past week. The three last-named railways ordered 150,000 tons of open-hearth rails from the Tennesee Coal & Iron Co. Of this total 40,000 tons are for the Illinois Central, and 110,000 tons for the Union Pacific—Southern Pacific system. The Pennsylvania R. R. orders amount to 142,000 tons, about half of which goes to the United States Steel Corporation, about 30,000 tons each to the Pennsylvania Steel Co. and the Cambria Steel Co., and 10,000 tons to the Lackawanna Steel Co. The entire order, it is reported, is for Bessemer rails.

RUNNING LEVELS WITH THE TRANSIT has been extensively practiced on the Wisconsin water power surveys. Results obtained are described by Prof. L. S. Smith, of the University of Wisconsin, the Chief Engineer in charge of the surveys, in a recent paper in the "Wisconsin Engineer." It was found that the probable errors in transit leveling were from 0.01 ft. to 0.33 ft. per mile; and that the errors were compensating, so that the total probable error from a line of transit levels 200 miles long would be only 0.75 ft. Prof. Smith says:

Attention is directed not so much to the small size of the errors as to the fact that the errors compensate to a remarkable degree. It is perfectly manifest that the transit as a leveling instrument is capable of doing leveling with an accuracy well within the limits required on preliminary surveys.

The cost of the Wisconsin River surveys per mile varied from $8.29 to $12.71.

PERSONALS.

Mr. W. H. Jeffrey has been appointed to the superintendency of the La Rose Mines Co., in the Cobalt district, Ontario.

Messrs. W. B. Devereux & Sons, mining engineers, are now located at 15 William St., New York; their former offices were at 99 John St.

Mr. Arnold I. Brosius has been appointed assayer and surveyor for the Victoria Chief Copper Mining & Smelting Co., at Engle, N. Mex.

Mr. Charles L. Parmelee, C. E., has removed his offices from Los Angeles, Cal., to the West Street Bldg., 90 West St., New York City.

Mr. B. H. Rader has been appointed Eastern Sales Agent of the Universal Portland Cement Co., of Chicago, with offices in the Frick Building, Pittsburg.

Mr. S. S. Bruce, of New York, has been appointed to a position on the engineering staff of the American Smelting & Refining Co., with headquarters at Salt Lake City, Utah.

Mr. W. M. Fawcett, formerly Shop Superintendent for Julian Scholl & Co., Kingston, N. Y., has been appointed to a position as Mechanical Engineer with the Stearns Co., of Erie, Pa.

Mr. J. R. Strange, until recently with the Payne Engineering Company, has been appointed AssistantEngineer of The Mingo Block Coal Company, with headquarters at Williamson, W. Va.

Mr. Geo. C. Manning has been promoted from contracting to traveling freight agent of the New York division of the Erie R. R. He is succeeded at Buffalo by Mr. Walter C. Morgan.

Mr. M. C. Sturtevant, General Assistant with the Grand Trunk Ry. and next in executive control to Mr. F. W. Morse, has resigned that position and will engage in contracting work.

Mr. M. D. Fahey has been appointed Superintendent of the Mississippi Central R. R. to succeed Mr. M. H. McCabe; the latter resigned to accept a similar position with the Norfolk & Western Ry.

Mr. Peter Anderson, President of the North Poudre Irrigation Co., at Fort Collins, Colo., resigned on May 3. Mr. F. N. B. Scott was elected to succeed him. Mr. Watson Ziegler was elected Vice-President.

Mr. E. M. Grime has resigned as Division Engineer of the Chicago Great Western Ry., at St. Paul, and has accepted a position in the Engineering Department of the Northern Pacific Ry., with headquarters at St. Paul.

Messrs. R. R. Carr-Harris and John Hutton, of the engineering staff of the Guelph and Goderich R. R. (Ontario) have been appointed to positions on the engineering staff of the Canton and Hankow R. R. They left for China on May 15.

Mr. A. W. Park recently accepted a position on the engineering-sales staff of the John A. Traylor Machinery Co., of Denver. He has previously been associated with the Mine & Smelter Supply Co. and with the Joshua Hendy Iron Works Co., of San Francisco.

Mr. Charles B. Ball, M. Am. Soc. C. E., has been appointed Chief Sanitary Inspector for the city of Chicago. A competitive examination for this position was held by the Civil Service Commission in January, 1904, and Mr. Ball passed at the head of the list.

Mr. W. W. Yeatman, formerly Chief Despatcher of the Tennessee Central R. R., and later of the Southern Ry., at Nashville, Tenn., has been appointed Superintendent of the Orange Division of the Colorado Southern, New Orleans & Pacific R. R., with headquarters at Orange, Tex.

Mr. C. C. Boyer, Assoc. M. Am. Soc. C. E., has been appointed Resident Engineer of the Beaumont Division of the Atchison, Topeka & Santa Fe Ry., with headquarters at Beaumont, Tex. He succeeds Mr. R. A. Rutledge, who has been transferred to another division.

Mr. V. E. McBee, Jr., Resident Engineer of the Seaboard Air Line Ry., at Birmingham, Ala., was married on April 30 to Miss Mabel Hudgins, daughter of the late T. L. Hudgins, one of Birmingham's leading men. Mr. McBee is the son of Col. V. E. McBee, who was formerly Acting General Manager and General Superintendent of the Seaboard.

Prof. Francis Humphrey Storer, of the Chair of Agricultural Chemistry at Harvard, and Dean of the Bussey Institution, has resigned. The resignation will take effect Sept. 1. He has occupied this chair since Nov. 25, 1870, and has as Dean of the institution been an excellent administrator. The Board of Overseers has made him Professor Emeritus from Sept. 1.

Mr. Robert Blickensderfer, former General Manager of the Wabash R. R., east of Toledo, who has been Consulting Engineer of the Wheeling & Lake Erie R. R. since Mr. F. Delano was elected President, has severed all connections with the Gould interests, and, it is said, will retire to his farm near Lebanon, Mo. He has also resigned as director of the Wheeling & Lake Erie.

Mr. Abel I. Culver has resigned as Second Vice-President and General Manager of the Delaware & Hudson Co. He will continue his duties in the former capacity until June 1. Mr. Clifford S. Sims, formerly General Manager of the Baltimore and Ohio R. R., and lately Assistant to the President of the Erie R. R., has been appointed to succeed Mr. Culver as General Manager.

Mr. Geo. H. Frost, President of the Engineering News Publishing Co., and founder, in 1874, of Engineering News, was elected a member of the Canadian Society of Civil Engineers on May 2. Mr. Frost is still active in the business management of this journal as well as being Managing Editor of the "Daily Courier-News" of Plainfield, N. J., of which journal he is also sole owner.

Mr. M. E. MacDonald has resigned as General Manager of the Guanajuato Consolidated Mining & Milling Co.'s interests at Guanajuato, Mex.; he will continue his connection with the company, however, as consulting engineer, with headquarters for the company's business at its New York office, 35 Wall St., and offices for his private business at 40 Wall St.

Mr. Barrett B. Mitchell, who in 1867 entered the employ of the Vanderbilt lines as office boy at $3 per week, was appointed on May 10 to the position of General Freight Traffic Manager of these lines. His headquarters will be at Chicago, but he will maintain an office in the Grand Central Station at New York. From 1896 to 1905 he held the position of General Freight Agent; and from 1905 until the death, two months ago, of Capt. G. J. Grammer, then General Freight Traffic Manager, he was Freight Traffic Manager at Chicago.

Mr. Carl W. Bucholtz, M. Am. Soc. C. E., Consulting Engineer with the Erie R. R., suffered a painful operation on April 12 at St. Luke's Hospital, New York. A congested artery in his right foot made the amputation of that member necessary at a point between the knee and ankle; he had been incapacitated since March 5 by the trouble which led to the operation, and now, having been at his home again only since May 9, we are happy to report that his recovery is progressing so rapidly that he will probably be able to be about by the end of a fortnight.

Mention was made in this column last week of the resignation of Prof. Mansfield Merriman of the Chair of Civil Engineering at Lehigh University. We are moved to amplify that mere mention in view of Prof. Merriman's well earned eminence in his field. For 28 years he has been in the service of the university; and during that period he has, through his valuable contributions to engineering literature—notably in bridge engineering and hydraulics—achieved a prominence such as has been attained by very few engineers engaged in the work of teaching. A graduate of Yale in 1871, he was from 1874 to 1878 instructor in civil engineering in the Sheffield Scientific School of that university. Other notable positions which he has held, incidental to his principal activity at Lehigh University, are: Assistant Engineer, U. S. Eng. Corps, 1873; Acting Assistant, U. S. Coast and Geodetic Survey, 1880 to 1885; Associate Editor Johnson's Cyclopedia, 1892 to 1896; Vice-President of the American Association for the Advancement of Science, 1894; President of the Society for the Promotion of Engineering Education, 1896, and President of the American Section of the International Association for Testing Materials, 1899. A year ago Lehigh University, in recognition of Professor Merriman's 28 years of continuous service, granted him a year's leave of absence; and he has during that time been carrying on a consulting engineering practice. This work he has found so congenial that he has now decided to continue in it instead of returning to work in the class room.

Prof. Frank P. McKibben, of the Massachusetts Institute of Technology, has been appointed Professor of Civil Engineering at Lehigh University, in place of Prof. Mansfield Merriman, who has resigned after a record of 28 years' service. Professor McKibben's experience as a teacher and his reputation as an engineer give assurance that the work of this great engineering school will be continued on its past high plane of efficiency. He studied at the University of Arkansas for three years before entering the Massachusetts Institute of Technology, from which institution he graduated in 1894, with the degree of B. S. in civil engineering. Since graduation he has been teaching in the Department of Civil Engineering of the Institute and in addition has been engaged in engineering practice, mostly in connection with the designing and construction of bridges, buildings and various other structures. He has had experience with several bridge companies, and for two years was Assistant Engineer of the Boston Elevated Railway Company. In 1901 he was made Assistant Engineer of the Massachusetts Railroad Commission, a position which he has held since that date, and from 1902 to 1907 was Librarian of the Boston Society of Civil Engineers. At present he is Associate Professor of Civil Engineering in the Institute of Technology. He is a member of the American Society of Civil Engineers; of the American Society for Testing Materials; of the American Society for the Promotion of Engineering Education, and of the Boston Society of Civil Engineers. Professor McKibben will assume the duties of his new office on Sept. 1, 1907, when Professor Merriman's resignation takes effect.

Obituary.

Georges de la Bouglise, a prominent European mining engineer, died at his home in Paris on April 15 at the age of 65.

Wm. M. Cook, of Auburn, N. Y., President of the Cullman & Southwestern R. R. Co., of Alabama, and of the Globe Coal & Coke Co., of Cullman, Ala., died of heart disease on May 13 at the Grand Pacific Hotel, Chicago.

Frank H. Goodyear, President of the Buffalo & Susquehanna R. R. and a prominent Buffalo capitalist, died at his home in Buffalo on May 13. He was one of the principal owners of the Goodyear Lumber Co., of Buffalo, and of the Buffalo & Susquehanna Iron Works of that city, as well as of a transportation line on the Great Lakes.

Albert Keep, formerly President of the Chicago & Northwestern Ry., died at his home in Chicago on May 12 at the age of 81. At the time of his death he was still a director with that road, and was a director of the Lake Shore & Michigan Southern R. R. from 1865 to 1883. He was prominent in financial and philanthropic work in Chicago.

Willis S. Essen, a young civil engineer of the Philadelphia Bureau of City Surveys, was struck and killed on May 8, while at work, by the Buffalo Express on the Philadelphia & Reading Ry. He was engaged in supervising the grade-crossing work in the elevation of the tracks of that road in the city of Philadelphia. Only last year he was graduated from the Department of Civil Engineering of the University of Pennsylvania.

Nathan Guilford, late Vice-President of the New York Central & Hudson River R. R., died at his home in Yonkers, N. Y., on May 11 at the age of 66 years. He was born in Cincinnati; in 1859 he entered the freight department of the Little Miami R .R., where he remained until 1867; from 1869 to 1870 he was Secretary to the President of that road. He was then appointed Assistant General Freight Agent of the Baltimore & Ohio R. R., and from 1872 to 1877 served as its General Freight Agent. Since 1877 he has held various positions with different roads, and has been regarded as an authority on railroad management.

Hill Hamilton Filley, M. Am. Soc. C. E., died at Colorado Springs, Colo., on May 6 at the age of 60 years. His professional career had been an extensive one, beginning in 1871 with his employment a srodman with the Buffalo, New York & Philadelphia R. R. During 1882 he was with the Canada Southern R. R. on the survey of the Michigan Midland R. R., and also Resident Engineer in the construction of the Toledo, C. S. & Detroit R. R. From 1873 to 1880 he had been First Assistant City Engineer at Toledo, Ohio. Later he was located in Mexico, and for a number of years was Chief Engineer of the Mexican National Construction Co., and later Chief Engineer and General Manager of the Guanajuato Power & Electric Co. His residence for 20 years has been at Kansas City.

James T. Ford, M. Inst. C. E., for many years connected with railway and other enterprises in Central America, committed suicide on May 3 while on a voyage to England. A press dispatch from Plymouth, England, May 7, says:

Mr. Ford, who was ill when he went on board the steamer, was accompanied by his wife and a medical attendant. On May 3, while going to breakfast, he became frenzied on deck and threw himself into the sea, in full view of the passengers. The ship was stopped and the body was recovered.

Mr. Ford was a member of the engineering staff of the old Nicaragua Canal Co. and in recent years had been Consulting Engineer to the Government of Colombia. He was a frequent contributor to the columns of Engineering News.

Charles Haynes Haswell, without doubt the oldest member of the engineering profession, died on Sunday, May 12, at his home at 324 West 78th St., New York, from the effects of a fall on the day previous. Had he lived ten days longer he would have been 98 years of age. Although in our issue of June 2, 1904, there appeared a very complete historical sketch of Mr. Haswell's life, it will not be out of place to mention again here the leading facts. In 1843 Congress commissioned him Engineer-in-Chief of the United States Navy, a position which he occupied for eight years. From 1851 he was engaged in the private practice of civil and mechanical engineering in New York City, and there served in many positions of responsibility, both of an engineering and a political nature. He it was to whom credit is due for the creation of the modern steam yacht—his "Sweetheart," designed and built before 1840 at the Brooklyn Navy Yard, being the Eve of vessels of that class. In 1847-48 he designed the complete engine and boiler equipment of the U. S. S. "Powhatan," which war vessel did long, efficient service in the navy and was the oldest steam war vessel in active service when taken out of commission in 1886, with her machinery then substantially as it came from its designer's hands. Active service in the Civil War, though he was advanced in age when it broke out, was by no means the least of his achievements. His contributions to engineering literature, particularly his "Engineers' and Mechanics' Pocket Book," require no eulogy here. He was a member of the American Yacht Club and the Union Club of New York, being the Dean and oldest living member of the latter, the Engineers' Club of Philadelphia; the American Society of Civil Engineers; the British Institution of Civil Engineers; the Institution of Naval Engineers of Great Britain, and the Naval Engineers of the United States; the Society of Municipal Engineers of New York; the American Institute of Architects; the New York Academy of Science; the New York Microscopical Society and Society of Authors; and an Honorary Member of the Boston Society of Civil Engineers.

ENGINEERING SOCIETIES.

COMING MEETINGS

NATIONAL ASSOCIATION OF MANUFACTURERS.
May 20-22. Annual convention at New York City. Secy., Marshall Cushing, 170 Broadway, New York.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 21-24. Annual convention at Philadelphia, Pa. Secy., Richard Moldenke, Watchung, N. J.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22-24. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 28-31. Semi-annual meeting at Indianapolis, Ind. Secy., Mr. Calvin W. Rice, Engineering Societies Bldg., 33 West 39th St., New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 4 to 7. Annual convention at Washington, D. C. Secy., W. C. L. Eglin, 29 West 39th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 12-14. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN WATER-WORKS ASSOCIATION.
June 17-22. Annual convention at Toronto, Ont. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19, 20. Annual meeting at Atlantic City, N. J. Secy., P. W. Drew, Wisconsin Central Ry., Milwaukee, Wis.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 20-22. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Annual convention at the City of Mexico, Mexico, beginning July 8. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
June 25, 26. Annual meeting at St. Paul, Minn. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Niagara Falls, N. Y. Secy., Ralph W. Pope, 29 West 39th St., New York City.

NATIONAL MUNICIPAL LEAGUE.—The Business Committee has accepted the invitation of numerous Providence organizations to hold the next annual meeting of the league in that city next November, in conjunction with the American Civic Association.

THE NATIONAL ASSOCIATION OF MANUFACTURERS will hold its twelfth annual convention and banquet on May 20, 21 and 22, at the Waldorf-Astoria Hotel, New York City. Parts of three days are to be devoted to the business sessions of the convention, during which addresses are to be made on some of the most important topics now before the business world, by government officials, manufacturers and others prominently identified with these subjects. The annual banquet is to be held on the evening of Wednesday, May 22.

Among the speakers at the business sessions will be: Hon. Charles A. Prouty, of the Interstate Commerce Commission, on "Further Railroad Legislation"; Hon. Francis B. Loomis, formerly Assistant Secretary of State, on "Some Practical Results of the Convention Reform Agitation"; Mr. Charles M. Pepper, special agent of the Department of Commerce and Labor to investigate trade conditions in foreign countries, on "Foreign Trade: How to Get It and Keep It"; Dr. Charles P. Neill, Commissioner of Labor, Department of Commerce and Labor, on "Certain Aspects of the Child Labor Problem"; Mr. Arthur D. Dean, on "Trade Schools; the Manufacturer's or the Pedagogue's Sort"; Captain Henry A. Castle, late Auditor of the Treasury for the Post Office Department, on "Needed Postal Reform."

The chief speakers at the banquet will be Hon. Oscar S. Straus, Secretary of Commerce and Labor; Senator J. P. Dolliver, of Iowa, who has promised that his address shall be on "The Revolt of the Unincorporated"; Rear-Admiral Charles D. Sigsbee, for the Navy; Major General J. Franklin Bell, chief of Staff, for the Army, and Rev. Dr. Joseph Dunn Burrell, whose topic will be "The Era of Work."

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, May 16, 1907.

CONTENTS.

REVIEWS:
Practical Illumination. Reviewed by L. B. Marks 549
Graphical Handbook for Reinforced Concrete Design. Reviewed by Arthur N. Talbot..... 550
The Wonders of the Colorado Desert..... 550
Sanitary Engineering with Respect to Water Supply and Sewage Disposal..... 551
Concrete Tests at University of Illinois..... 551
The Chemistry and Technology of Mixed Paints. Reviewed by Robert Job..... 552
The Dangers of Municipal Ownership.—Municipal and National Trading 553
Hydrometallurgy of Silver. Reviewed by Bradley Stoughton 554
Handbuch für Eisenbetonbau..... 554
The Causes of Decay in a British Industry..... 555
The Complete Automobile Instructor..... 555
The Engineering Index..... 556
Disinfectant Value of Chlorine..... 556
PUBLICATIONS RECEIVED 556

REVIEWS.

A New Book on the Art of Illuminating.

Reviewed by L. B. MARKS.*

PRACTICAL ILLUMINATION.—By James Raley Cravath and Van Rensselaer Lansingh. New York: McGraw Publishing Co. Cloth; 6 × 9½ ins.; pp. 356; 370 illustrations in the text and 3 plates. $3, net.

Up to within recent years the literature of the science and art of illumination was very scanty. Numerous articles on this subject had appeared from time to time in the technical journals and elsewhere, but it remained for Dr. Louis Bell to give us the first book in which the subject was treated at length both from a theoretical and practical standpoint and in which the scattered data on the subject were brought together and presented in an authoritative work. Since the first issue of Dr. Bell's book a remarkable development has taken place in the scientific study of the subject of illumination. Illuminating engineering, which until a comparatively few years ago was almost unknown, has now become a recognized specialty. In their treatment of some of the practical questions that come up in the design of illumination, Messrs. Cravath and Lansingh have given us in their book on "Practical Illumination," just issued by the McGraw press, an admirable supplement to the work of Dr. Bell.

The authors, in the preface to their book, point out that their object is "to present exact practical information of every-day use on many points that come up in arranging artificial lighting." They make no attempt to treat of the apparatus for the production of light, but rather to confine the work to the much neglected subject of how best to use the light after it is produced. A great many tests are shown giving information on the light distribution of various illuminants with different globes, reflectors and shades. Much of this information has not before been available to the general user. All of the tests in the book, with the exception of a few which are noted in the text, were made by the Electrical Testing Laboratories of New York City. The tests have thus the advantage of being from a uniform unbiased source.

The authors do not attempt to lay down the broad general principles which should be followed in the design of artificial illumination. They aim rather to give specific data and suggestions as to how to carry out these principles in practice. The numerous curves which they present and the deductions which they make from these curves go far toward supplying the information which they set out to give.

The plan which they adopt to show alongside of each curve of light-distribution, a picture of the globe, shade or reflector from which this curve was taken, is admirable, as the reader can tell at a glance just what the curve refers to. This feature could have been made even more practical if the authors had stated in the caption under each curve, where possible, the candle-power and type of the lamp referred to.

A unique part of the book is the publication of an appendix giving the manufacturers' names and numbers or trade designations of the reflectors, shades and globes upon which tests are given in the body of the book. It is to be regretted that some very useful shades for the diffusion of illumination are not referred to either in the text or in the appendix. Take for instance the diffusing reflector of Zalinski. This reflector has a definite place in the art and can be used in some cases by the illuminating engineer to better advantage than almost any other type. In their treatment of the subject of illumination the authors refrain as far as possible from the use of mathematics. For this reason much of the information given in the book is in such shape that while being of value to the technical men it can be read with profit and applied by the layman as well.

If the suggestions given by the authors in the short chapter on "Light and the Eye" are followed by the general public, we may look for marked improvement in the eyesight of the coming generation. This chapter emphasizes the importance of a subject, the neglect of which has resulted not only in monetary loss but what is far worse, in physical disability due to impaired eyesight. In the report of the Committee on Elementary Schools (Board of Education, New York), published just before the appearance of this book, the following statement is made: "It is estimated that there are at present 36,000 children in the public schools (of New York City) who are suffering from defective vision to such an extent as seriously to retard both physical and intellectual development." It is now a well recognized fact that one of the causes that lead to defective eyesight is the exposure of the eyes to the glare of bright lights that are commonly placed within the ordinary field of vision. It is refreshing to note that in almost every chapter of their book the authors have taken the opportunity to warn their readers against the use of bright exposed lights.

The authors have adhered to the foot-candle as the unit of intensity of illumination on any surface upon which light might fall. They have inadvertently used the plural "candle-feet" instead of foot-candles in a number of places in the chapter on "Calculation of Illumination." They treat exhaustively of incandescent electric lamps and their reflectors, shades and globes, and also of gas burners, acetylene burners, Nernst lamps, electric arc lamps, vapor tube lamps, etc. The treatment of both gas and electric lamps in the same work gives a good opportunity for speedy comparison of the performance of these types of illuminants. The authors might with advantage have added a chapter on oil lamps. In the chapter on "Arc Lamps" the performance of various types of ceiling diffusers might with advantage have been dwelt upon briefly.

The rapid development in the field of electric illuminants is well shown by the fact that since the book of the authors went to press the tungsten lamp, which bids fair to work quite a revolution in electric lighting by incandescent lamps, has been placed on the market in the United States.

The chapter on "Demonstration Room Tests" is unique. The illustrations given in this chapter show visually to the layman what he might not adequately conceive from an examination of the candle-power curves.

In the chapter on "Comparison of Illuminants" the amount of light per KW. hour or the mean spherical candle-power hours per KW. hour is given for various kinds of lamps. In considering the question of practical illumination, one of the important and in some cases vital considerations, is the question of cost of the light. The authors undoubtedly felt that this question hardly comes within the province of their book, but it is to be hoped that they will supplement some of the data on illumination by actual figures showing the cost of operation under different conditions. Such data, for instance, added to the table in the chapter on "Comparison of Illuminants" would add immensely to the value of the table. Referring to the table of the performance of electric lamps in this chapter, care should be taken in interpreting the results. For instance, it is a well known fact that the direct-current arc lamp is a more efficient light producer than the alternating current arc. Yet to one unskilled in the art, the inference might easily be drawn from the figures given in the table that the reverse is the case.

Of the 350 odd pages in the book, considerably over half are devoted to the presentation and discussion of practical examples of interior lighting arrangements, both good and bad. The authors believe that by this method a much clearer idea of what constitutes good and bad design can be obtained than by a discussion of abstract general principles. They illustrate all of their cases by photographs of actual interiors. They take up residence lighting, office lighting, the lighting of public halls, depots, banquet rooms, theaters, libraries, etc. They give illustrations of good and bad car lighting, store lighting, show window lighting, shop and factory lighting, and miscellaneous examples, such as the lighting of billiard rooms, barber shops, banks and hospitals.

In some cases they give the dimensions of the rooms illustrated and discussed, and the watts consumed per square foot of floor space. As a rule, however, these data are not given, the authors simply pointing out where, in their opinion, the layout is good or bad and why. The value of this portion (which constitutes the second half) of the book would be greatly enhanced if the authors could have given more complete data as to the number, candle power and exact type of lamps used, dimensions of the rooms, color of the walls and furniture and actual measurements of foot-candles of illumination delivered. As before stated, economy is a most important consideration in many cases, not only in the cost of illumination but also in the initial cost of the installation. For this reason the question of proper switching arrangements often plays an important part in the design of practical illumination. The authors touch only casually on this phase of the subject. The design of fixtures for the proper distribution of illumination must also be considered in connection with that portion of any work which deals with the best results that can be obtained from the current available at the outlet. The authors have put in a plea for more rational fixture design and have offered some suggestions in this direction. They might well have elaborated on this important branch of the subject without having transgressed the scope of the book.

Taken all in all the book may be truly said to constitute a real contribution to the literature of the art of practical illumination. It goes without saying that it should find a place in the library of every illuminating engineer. But the illuminating engineer is not the only one to whom the book will appeal. The authors happily have presented the subject in such a way that the architect, the contractor and the central station man will derive much benefit from reading it.

*Illuminating Engineer, 220 Broadway, N. Y. City.

Diagrams for Reinforced Concrete Design.

Reviewed by ARTHUR N. TALBOT.*

GRAPHICAL HANDBOOK FOR REINFORCED CONCRETE DESIGN.—By John Hawkesworth, Engineer with Raymond F. Almirall, Archt. New York: D. Van Nostrand Co. Cloth; 8½ × 11¼ ins.; pp. 64; 15 plates and 2 text illustrations. $2.50, net.

This book contains 15 plates of diagrams for use in determining the size and the amount of reinforcement for floors, beams and columns of reinforced concrete construction. These diagrams give the safe resisting moment of beams with percentages of reinforcing up to 3%, the resisting moment of slabs of different thicknesses reinforced in one direction, the bending moment in pier footings, the resisting moment of beams and slabs of depths up to 21 ins., position of the neutral axis, shearing resistance of beams, allowable load on columns with longitudinal steel reinforcement of various percentages, loads on hooped columns, various graphical multiplication tables, and a design of a reinforced concrete structure. The appendix gives the derivation of the formulas for rectangular beams and T-beams, for columns with longitudinal reinforcement, and for hooped columns, and also the requirements of the building code of New York City in regard to reinforced concrete.

The plates are 7 × 9 ins. in size, with five folding plates double this size. The diagrams are well executed, clear and conveniently arranged for use, and the explanations and examples which accompany them are clear and to the point. The scale is sufficiently large for office use.

The worth and usefulness of the book must depend, also, upon the soundness of the principles and the fitness of the constants used in the construction of the diagrams. An examination of the basis of the diagrams is therefore essential in judging the book. The limiting unit stresses and constants used, the author states, are those prescribed by the building code of New York City. For flexure, these values are 16,000 lbs. per sq. in. tensile stress in the steel and 500 lbs. per sq. in. compressive stress in the concrete, with 12 as the ratio of modulus of elasticity of steel to modulus of elasticity of concrete. As the results obtained with the use of a straight-line or constant stress-deformation relation (as intended by the New York building regulations) are believed by the author to be less than conservative practice requires, he uses the parabolic stress-deformation relation in an effort to offset the effect produced by the low constants prescribed by the building regulations. In carrying this out he overlooks, or fails to accept, the necessity for using a value of the modulus of elasticity for the concrete in the parabolic formula only one-half as great, or but little more than one-half as great, as the value specified for the straight-line stress-deformation relation. The use of the true relation will make an appreciable change in the calculated strength of the beams, especially for all cases where the compressive strength of the concrete is the controlling element. Instead of a .56% reinforcement being the limit beyond which the compressive strength of the concrete controls the resisting moment of the beam, as given by the diagrams, this limitation will not appear, even with the comparatively low value of the compressive unit-stress specified, until the reinforcement reaches about .9%. The revised calculation will give, for a .9% reinforcement, about 25% greater bending moment than that shown by the diagrams, and this discrepancy will continue for the higher reinforcements. It may be added that this limit of .9%, as the amount beyond which the compressive strength of the concrete controls the strength of the beam, is conservative. The view that a higher compressive stress than that intended in this law may be permitted seems reasonable when the restraining influence of the lower layers of concrete is considered.

In connection with Plate X., it is not clear why a building law should specify that 200 times as much shearing stress will come upon a square inch of steel as upon a square inch of concrete, when for tensile and compressive stresses a ratio of 12 is designated. Nor does it seem reasonable to use the area of the flanges of the T-beam in the shear calculation if the results are to be used to measure the ability of the beam to resist diagonal tension.

The diagrams for columns reinforced with longitudinal rods are based upon a ratio of moduli of elasticity of 12, as specified in the New York City building law. Plate XII. gives loads for unit-stresses ranging from 350 lbs. per sq. in. (specified by these building regulations) to 800 lbs. per sq. in. The diagrams for hooped columns (not covered in the building regulations) specify a distance of one-sixth of the diameter of the hooped core between spirals of the hooping, a tension of 25,000 lbs. per sq. in. in the hooping wire, and a compression on concrete core of 1,000 lbs. per sq. in. safe load. The formulas for hooped columns are unlike those commonly quoted. They are based upon a lateral pressure of about one-fourteenth the longitudinal pressure (considered to be taken by the tension in the hoops), and no allowance is made otherwise for the strength of the concrete itself. This lateral expansive pressure is determined by assuming that the "angle of stability of concrete under compression, from the experiments that have been made, is 60°." As an angle of 50° will, by the formula used, give twice as much lateral pressure, and an angle of 70° one-half as much, it would seem wise, considering the limitations in the present knowledge of hooped columns, not to place much reliance on a formula based on a round number. The treatment of the longitudinal rods included in the design of hooped columns is inconsistent. Altogether, the diagram for hooped columns is of dubious value. Nothing is given on the amount of shortening and bending in these hooped columns.

Plate XV. gives what is called a complete design of a reinforced concrete structure. This design is open to considerable criticism. To illustrate, the girder is designed as a T-beam, the bending moment at the middle of its length is calculated as a simple beam with a concentrated load in the middle (which accords with the building regulations), but, although the end construction is such as to give considerable restraint, no attention is given to the end condition, neither the position of the reinforcing bars nor the compressive strength at the bottom of the beam being designed to carry end constraint. The stirrups used are insignificant, and the web reinforcement is insufficient. Such defects render of doubtful applicability the remark in the preface that a book of this class will make it unnecessary to call in expert assistance in the solution of the problems ordinarily encountered.

Graphical representations have advantages over tabular statements, and these diagrams are to be commended for their simplicity, clearness and convenient form. Such criticisms as are given here show a limit to their usefulness, but it must be remembered that these limitations are partly inherent in the building regulations followed.

*Professor of Municipal and Sanitary Engineering and in Charge of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

PROCEEDINGS AT THE DEDICATION OF THE NEW ENGINEERING BUILDING AT THE UNIVERSITY OF PENNSYLVANIA.—Cloth; 7 × 10 ins.; pp. 67. Published by the University.

This handsome volume records in permanent form the dedication exercises of the University of Pennsylvania's fine new engineering building, which took place last October. The event was a noteworthy one in the annals of American engineering and deserving of permanent record.

EARTHQUAKE AND FIRE, 1906. SAN FRANCISCO.—Observations, Criticisms, Comparisons and Opinions on Fire Prevention. (By E. S. Hand, Installation Engineer, Mississippi Wire Glass Co., 277 Broadway, New York.) Cloth; 6 × 9¼ ins.; pp. 90; illustrated.

This is a compilation of opinions and conclusions by prominent authorities on the San Francisco earthquake and fire of April, 1906. Naturally the compilation is made in such a manner as to bring out clearly the advantages of interior and exterior barriers to the spread of flames.

The Colorado Desert.

THE WONDERS OF THE COLORADO DESERT.—(Southern California.) Its Rivers and Its Mountains, Its Canyons and Its Springs, Its Life and Its Story, Pictured and Described. Including an Account of a Recent Journey Made Down the Overflow of the Colorado River to the Mysterious Salton Sea. By Charles Wharton James, Author of "In and Around the Grand Canyon," etc. In Two Volumes. Boston, Mass.: Little, Brown & Co. Cloth; 5½ × 9 ins.; pp. xxiv. + 547; folding and other plates and numerous text illustrations. $5, net.

The Colorado Desert has been of passing interest to many and of great interest to few ever since it was first visited by Spaniards several centuries ago. This interest has been largely due to its completeness as a desert and to the fact that a considerable portion of its area is below sea level. Of late public attention has been directed to the desert because of the rapid reclamation and settlement of portions of it by means of irrigation, and because of the break of the Colorado River back into the old Salton Basin. The successful closure of the break after a struggle unparalleled in the history of engineering, as recently described at length in Engineering News, renders the two handsome volumes before us particularly timely.

The book gives evidence of having been written by a diligent student of the Colorado Desert, who has gained at first hand no inconsiderable portion of his information. For the most part it is very readable. It might, perhaps, have been improved by curtailing the matter which has been either quoted or paraphrased. The reputation of the illustrator would have been greater had a number of the more amateur sketches of the artist been omitted. By condensing the text, reducing the number of sketches and using a less heavy paper the book might readily have been presented in a single volume and at a lower price. It would have been a pity, though, to sacrifice any of the half tone reproductions of photographs, or to have altered the binding. For the latter, a remarkably tasteful combination of colors has been chosen, aptly representing the gray of the desert, the deep blue of the cloudless sky and the rich gold of the desert sunlight.

The book describes the desert as a whole and in detail, including its physical realities of rivers, mountains and sand storms, its various illusions, its marvelous colors and awful silences, its animal, plant and Indian life. It also describes the activities and achievements of white men on the desert, as explorers, stage line and ferry (Colorado River) proprietors, irrigators and farmers. The recent struggle with the Colorado River is outlined (up to November, 1906), and some interesting information regarding the irrigation companies and their financial difficulties is given. A number of journeys through the desert by the author and his friends are described, including a boat trip down the Colorado overflow channel to the Salton Sea. A separate chapter is devoted to the tragedies of the desert and another to sign boards. Recent steps to provide signs will lessen the number of future tragedies.

To many people who are quite ignorant of the Colorado Desert, and this includes nearly everyone outside the Desert and vicinity, the book will be full of pleasant surprises. Perhaps the chapters on the wild animals, birds, reptiles, insects and plant life of the Desert contain as many surprises as any in the book.

LEHRBUCH DER ELASTIZITAET.—By A. E. H. Love, M. A., D Sc., F R. S., Sedleian Professor of Theoretical Physics at Oxford University. Authorized German Edition by Dr. Aloys Timpe, Assistant at the Dantzic Technical College, with the Collaboration of the Author. Leipzig and Berlin, Germany: B. G. Teubner. Cloth; 6 × 9 ins.; pp. 664; 75 illustrations in the text. 16 marks; American price, $6.40.

An excellent work on the theory of stress and strain in solids—the theory of elasticity—is made available to German readers in the present translation. The original appears to be rendered with unusual accuracy and fidelity, the latter extending to the point of the introduction of new terms to translate such English words as "strain," "twist" and the like. The translation is based on the new edition of Love's "Treatise on the Theory of Elasticity," published in 1906. Excellence of paper, illustration, presswork and other essentials of book-making distinguish the work.

Water Supply and Sewerage.

SANITARY ENGINEERING WITH RESPECT TO WATER-SUPPLY AND SEWAGE DISPOSAL.—By Francis Vernon-Harcourt, M. Inst. C. E., Author of "Rivers and Canals," etc., Emeritus Professor of Civil Engineering and Surveying, University College, London, and British Member of the International Consultative Commission for the Suez Canal Works. London, New York and Bombay: Longmans, Green & Co. Cloth; 5¾ × 9 ins.; pp. 419; 287 illustrations in the text, 14s., net; American price, $4.50, net.

Writers of British engineering books have a habit of limiting sanitary engineering to water supply and sewerage, and sometimes to sewerage alone. Our present author states in his Preface a belief "that the two subjects Water-Supply and Sewage Disposal" form "in conjunction the basis of sanitary science." He goes outside this obviously narrow limit to the extent of devoting a very few pages to refuse disposal and destructors. Within the field thus delimited the author has produced a useful book. Its usefulness in this country, however, will consist chiefly in its collection of brief descriptions of detailed parts of water-works and sewerage systems. In fact, this will doubtless be the most valuable feature of the volume in England itself.

About three-fourths of the book is devoted to Water Supply, and even then the very important subject of pumping machinery is omitted. The inadequacy of a hundred pages or so for Sewerage may partly explain why sewage treatment is so briefly discussed. In neither section are the fundamental sanitary principles elaborated. In other words, the book deals with the constructional phases of sanitary engineering rather than with sanitation itself.

After a few pages on "ancient water-works" the author deals in succession with rainfall, sources of water supply in general and wells, lakes and storage reservoirs in particular. He then takes up earth and masonry dams, intakes, supply mains, service reservoirs, tanks and standpipes, water purification and water distribution, the latter including per capita consumption, mains, hydrants, house services and fittings and meters. The chapter on water purification is very inadequate, from the American viewpoint, as it contains practicaly nothing on such important topics as the removal of color, odors and tastes. This chapter is in contrast with many of the others on Water Supply in that it gives very little recognition to the large volume of valuable American literature on various phases of water purification.

The section on Sewerage opens with a chapter on house drainage and refuse disposal, in the course of which some phases of British plumbing practice are pictured and refuse destructors are briefly described. The next chapter deals with the separate and combined systems of sewerage and with sewage collection in general. Here there are a few paragraphs on sewage ejectors and lifts, but other means for lifting sewage are barely mentioned in the book. Outfall sewers, disposal by dilution, sewage clarification and sludge disposal at sea are next discussed. There then follows a chapter entitled "Utilization and Purification of Sewage on Land." In the final chapter of the book, two pages on chemical treatment are added to the three pages on the same subject given under the heading "Clarification"; a few words are then said on electrolytic processes, after which intermittent sand, contact, and sprinkling filters, the septic tank, upward filters, trades wastes and Local Government Board regulations of sewage treatment are taken up. The plan followed in discussing sewage treatment will suggest to those thoroughly conversant with the subject that the author is less familiar with that than with many other divisions of his book; and the text confirms that suggestion. We think we do the author no injustice in saying that throughout his book he writes like a person experienced in general civil engineering construction rather than like a sanitary engineer, at least as we in America now understand that term. Nevertheless he has epitomized a considerable part of water-works and sewerage practice, including purification in each field, and seems to have produced a book remarkably free from errors and vagaries. The examples of engineering construction, more particularly outside sewage and water treatment, are particularly commendable.

Concrete Tests at University of Illinois.

TESTS OF CONCRETE AND REINFORCED CONCRETE COLUMNS.—Series of 1906. By Arthur N. Talbot. Bulletin No. 10 of the University of Illinois Engineering Experiment Station. Urbana, Ill.: The University. Paper; 6 × 9 ins.; pp. 61; 37 illustrations, mostly in the text, and 12 tables.

TESTS OF REINFORCED CONCRETE T-BEAMS.—Series of 1906. By Arthur N. Talbot. Bulletin No. 12 of the University of Illinois Engineering Experiment Station. Urbana, Ill.: The University. Paper; 6 × 9 ins.; pp. 35; illustrated.

The work that Prof. Talbot is doing at the University of Illinois in the investigation of the phenomena of concrete has been conceived and executed in such complete and well-ordered form that it is one of the best series of tests we have on the subject. The two bulletins noted above are the fourth and fifth respectively of the concrete series, the other three being Bulletins Nos. 1 and 4 on Reinforced Concrete Beams and No. 8 on Shear and Bond in Concrete.

One of the puzzling elements in floor slab design has been the effect of the slab upon the strength of the beam, an effect which expresses itself in the design as the proportionate amount of slab to include in the T of the beam in the computation for strength. This determination together with the efficiency of vertical reinforcing stirrups in resisting web stresses, was the object in view in undertaking the tests. The results, while satisfying in themselves, do not cover a sufficient number of tests to make any absolute deductions, but add much to the data which are gradually making the design of reinforced concrete a more exact science.

The bulletin on column tests is of a more extended nature than that on the beams, and in addition to the mere mathematical deductions, comprises in itself a valuable discussion on concrete columns reinforced with vertical rods. Hooped columns were not tested in this series of experiments, but will be treated in a future bulletin. Besides the tabulation of results on these columns, the somewhat similar column-tests made at the Watertown Arsenal are summarized and analyzed in a like manner so as to show comparative results.

That extreme care is necessary in concrete column construction is very forcibly shown by the wide variation in results throughout the series of tests and also by the extremely low unit stresses at which some of the columns failed. In view of much current discussion as to working stresses in concrete columns, the following, taken from the bulletins, is of interest:

> It is hoped, however, that the data and discussion . . . . will perhaps serve to warn constructors against the use of high working stresses for columns constructed under ordinary working conditions with concrete of moderate quality.

A careful study of the tests and Prof. Talbot's deductions will well repay all designers of reinforced-concrete buildings where slabs and columns play so important a part.

TRAVELING ENGINEERS' ASSOCIATION.—Proceedings of the Annual Meeting held at Chicago, Ill., Aug. 28-31, 1906. (W. O. Thompson, Secy., Oswego, N. Y.) Leather; 6 × 8¾ ins.; pp. 414; illustrated.

The principal subjects discussed are front-end arrangements, the air-brake, the pooling of locomotives and the use of oil fuel. An abstract of the paper on the last subject was published in our issue of Jan. 10, 1907.

BEAUTIFYING AND IMPROVING GREENVILLE, SOUTH CAROLINA.—Report to the Municipal League, Greenville, S. C. Boston, Mass.: Kelsey & Guild (Landscape Architects). Paper; 6 × 9 ins.; pp. 48; illustrated.

It is gratifying to see such reports as this come from the press as rapidly as they have been doing for the last two or three years. In the present report the general city plan as it exists, and as it might better be, is discussed, after which various street improvements are suggested. Other topics discussed are the grouping of public buildings, needed sanitary improvements, parks, play-grounds and reservations, and the sanitary and esthetic improvement of Reedy River.

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CONGRES INTERNATIONAL DE TRAMWAYS ET DE CHEMINS DE FER D'INTERET LOCAL.—Report of the Fourteenth General Assembly, Held at Milan, Italy, Sept. 17-21, 1906. (P. t'Serstevens, Secy., 6, Impasse du Parc, Brussels, Belgium.) Paper; 8¼ × 13¼ ins.; pp. 382; illustrated.

The International Union of Tramways and Light Railways is a society composed of European, mostly continental, engineers for the study of the street railway situation, not only from an economic and technical standpoint, but with a view toward improving their value to the public. Their principal work consists of an annual meeting at which papers on subjects of special interest are presented and reports of committees read. The volume noted above is the report of the last of such annual meetings. It contains much valuable matter on light railway organization, superintendence and construction, as practiced to-day in Europe.

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Mixed Paints.

Reviewed by ROBERT JOB.*

THE CHEMISTRY AND TECHNOLOGY OF MIXED PAINTS.—By Maximilian Toch, Director of the Laboratory of Toch Brothers, New York City. New York: D. Van Nostrand Co. Cloth; 6 x 9¼ ins.; pp. xvi. + 166; plates and text illustrations. $3, net.

The agitation and discussion which has taken place in recent years regarding mixed paints has led to a strong impression in many quarters that the material is made solely upon a money-making basis, without regard for quality or durability in service. In some cases this idea is perfectly correct, as many have found to their sorrow. In the majority of instances, however, we have found in our practice that an effort is made not merely to secure a fair profit but to produce material which may be depended upon to give good service.

Mr. Toch's book marks a very creditable new departure by a paint manufacturer, the evident purpose being to explain the causes resulting in durability, and also to give many facts which are not commonly known to the general public, in order that the latter may be better able to determine the composition best adapted to any desired service. This discussion naturally brings up the subject of labels, and the inference is that as a mere matter of common honesty the statements should be correct, and not cunningly devised with a direct effort to deceive. Furthermore, it is a matter of common sense that a manufacturer loses nothing by being frank as to the general composition of his paints, for the day of secrecy and "rule of thumb" methods is pretty well past, and the present tendency is toward the effort to sell by proving the superiority of the manufacture.

The use of inert materials is a most important subject, affecting both service and cost of material. The ground is taken, and it is perfectly correct, that inert materials, such as silica, clay, etc., when in good physical condition (finely divided), and of proper purity, should be used in most paints in order to obtain the greatest service value—all this entirely apart from questions of cost. This inert matter, as it is technically called, is merely mineral matter, which is unacted upon by the oil or other paint vehicle—it has no coloring power and little opacity, and does not need them, since in a properly proportioned paint both properties are fully supplied by other ingredients. The presence of a fair proportion of this inert matter decreases the chemical action of oil upon pigment, and thus correspondingly increases the life of the paint. In the reviewer's extended experience as chemist of the Reading Railway, one of the paints which showed remarkable service value contained about 75% of inert matter (clay, silica, etc.) and about 25% of sesquioxide of iron. The latter proportion was ample to give proper hiding power to the paint, and a larger use in that paint would merely have increased the cost without adding benefit in any way.

Mr. Toch next takes up a discussion of various white pigments, notably white lead and zinc oxide. He shows the good points as well as the defects characteristic of each, and also gives a clear idea of the general methods of manufacture. Information is given, also, regarding other white pigments less generally known, such as "sublimed white lead," "zinc-lead-white," "lithopone," etc.

The different oxides of lead also receive due notice, and under "Red Pigments" a very useful discussion of the para-diazo reds is given. It is not many years since "mercury vermilion" was the great favorite for many signal purposes, and fancy prices were paid for it under the mistaken idea that it was the best signal red upon the market. Improvements in the manufacture of the "diazo" reds took place, and to-day the mercury reds are little used where exposed to the elements and particularly to sunshine.

Much discussion has been heard from time to time regarding the relative durability of the sesquioxide of iron pigments, and statements have been made as to their oxygen-carrying capacity. Mr. Toch's view is shown in his statement that "exhaustive tests made with some of the ferric oxides used as paints for the protection of iron and steel show that they are far superior to red lead and to graphite as paint protectors." This is in line with the reviewer's experience, although he has found both red lead and graphite paints of high service value when of suitable quality and properly applied. The statement is also made that "no argument can be adduced that ferric oxide is a carrier of oxygen, for it is a complete chemical compound; is not readily acted upon by dilute acids, nor affected by alkalies nor by sulphur gases, and as a paint the author has not been able to demonstrate that it reacts on linseed oil." In general the reviewer has found this correct, but recently he came upon a case in which strong action had taken place between the iron pigment and the oil, but investigation showed that a rancid linseed oil had been used, and hence the difficulty.

The author next gives a good description of the principal yellow, blue, green and black pigments, giving details of the various methods of manufacture, and a general description of the properties of these pigments. Lamp black paint is notoriously slow drying, and the author points out that this character is due to the contents of mineral oil derived from the method of manufacture, and directions are given for the removal of this matter, with the result of producing fairly rapid drying of the paint.

Under graphite paint the fact is mentioned that "the purer a paint pigment is as to its contents of carbon the poorer is the paint produced," and also that it is essential to reduce a graphite paint with a heavier base. One of the most durable paints with which the reviewer ever experimented was one which contained about 55% pure graphite, but the good results in this case were due to the fact that the entire pigment, silica as well as graphite, was in an exceedingly fine state of division. The reviewer has also seen graphite paints containing about 30% of carbon which gave very poor service owing to the coarseness of the pigment.

Several chapters are devoted to a discussion of the properties of the various fillers or extenders, such as silica, infusorial earth, barytes, carbonate of lime and clay, and also to the mixed paints. The subjects are of importance, since a clear conception of the principles involved is essential to the proper manufacture of the most serviceable paint.

Oils and other paint vehicles are next considered, and the properties and usual methods of analysis are given. Special mention is made of turpentine substitutes, and it is shown that satisfactory results can be obtained without the use of the old-time product, and at very much less cost, since the turpentine production is controlled by a few and the price is raised far beyond the intrinsic value. Other products are known which volatilize completely and at practically the same rate as turpentine and have good service value.

The theory of driers is also given, and it is shown why it is a fact—as is well known—that a dryer should be used in the smallest possible proportion, since its influence is to decrease the life of the coating, owing to the increased rate of oxidation consequent upon its use.

The author also gives reasons to prove that linseed oil is not porous, and an interesting account is detailed of experiements made to determine the products of oxidation of linseed oil.

A description of the properties of fish oil follows, and mention is made of its success as the vehicle in smoke stack paints. China wood oil or "tung oil" is described very fully, showing its characteristic properties, and particularly its waterproof qualities, which render it exceedingly serviceable in manufacture of marine and other water-resisting paints. The properties of benzol and benzine are given, and also general data regarding the composition of driers.

The question of water in paint is dealt with, and the statement is made that the proportion should not exceed 2%. In some grossly adulterated samples which have come under the notice of the reviewer as much as 25% of water has been present. To detect water in mixed paint several good qualitative schemes are given which will be useful to the analyst.

The author next takes up a discussion of various special paints, such as floor paint, cement paint, damp-resisting paints. Special attention is given to the composition of paints used in breweries. The last section of the book takes up the analysis of paint, including both pigment and oil, giving useful information as to the practical valuation of the material, while in an appendix consular reports regarding Chinese wood oil are reproduced.

The book throughout is illustrated with excellent photo-micrographs, which give a very clear insight into the relative appearance and size of the different materials and indicate, in some cases, the cause of difference in service value. Also a good index follows. Taken as a whole, the book will be found instructive and useful. Naturally, it does not give away trade secrets, but on the other hand, it contains much that is very little known by the general public, and it will well repay careful study.

*Member of the firm of Booth, Garrett & Blair, Analytical Chemist, 404 Locust St., Philadelphia, Pa.

BRUCKEN IN EISENBETON.—By C. Kersten. Part I. Slab and Girder Bridges. Berlin, Germany: Wilhelm Ernst & Son. Paper; 6¾ x 9¾ ins.; pp. 142; 360 illustrations in the text. 4 marks; American price, $1.60.

A descriptive treatment of slab and beam bridges built of reinforced concrete is given as a separate book in this work. Illustration, mainly by drawings, is abundantly used in exhibiting what has been done in this field, and together with the corresponding text in which these examples of work are mentioned or described they make up the substance of the work. Introductory chapters, of general tenor, and interpolated examples of computation, contain nothing of novelty or special value; the matter of surface finish and general design is particularly neglected. Like many European technical books, this one has the irritating fault of omitting to give titles under the illustrations.

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British Briefs Against Municipal Ownership.

THE DANGERS OF MUNICIPAL OWNERSHIP.—By Robert P. Porter, Director of Eleventh U. S. Census, Author of "Commerce and Industry of Japan," "Industrial Cuba," etc. New York: The Century Co. Cloth; 5½ × 8½ ins.; pp. 356. $1.80; postage, 20 cts.

ON MUNICIPAL AND NATIONAL TRADING.—By The Right Hon. Lord Avebury, P. C. London, England; Macmillan & Co. New York: The Macmillan Co. Cloth; 5½ × 9 ins.; pp. 178. 5s., net; American price, $1.00, net.

Mr. Robert Porter, having founded a high tariff newspaper, directed the taking of our eleventh census and performed other journalistic, statistical and political services, has returned to the land of his birth and now appears to be devoting himself to supplying public-service corporations and their sympathizers with British ammunition against municipal ownership. As a wholly partisan writer on his chosen subject, Mr. Porter is an unqualified success, except as his zeal defeats his own ends. His book, recorded above, is a well written marshalling of facts and arguments against what is known in England as municipal trading, all well adapted for use in any anti-municipal ownership campaign in the United States.

Lord Avebury (Sir John Lubbock), who has had a long and useful career as a scientist, statesman, banker and man of letters, has become so impressed by the recent "portentous and rapidly growing increase of rates [taxes] and municipal debt," and by the "great complexity, difficulty and importance" of the "duties entrusted to our local authorities," that he has felt called upon to review the case against municipal ownership. His book, it hardly need be said, is an able presentation of his subject. While less partisan and more dignified than Mr. Porter, Lord Avebury is seldom thoroughly judicial in his treatment of his subject. Such partianship as he exhibits is largely excusable, however, in view of the fact that he, in common with many other Englishmen, is little less than panic stricken by the multifarious activities of British towns, the increase of municipal debts, the fear that taxes will rise until private property will be either exhausted thereby or else driven from Great Britain. Scarcely less disturbing to Lord Avebury is the departure of the British town councils from the good old doctrines of Adam Smith, and the later teachings of Herbert Spencer, both deprecating the extension of state or municipal activities beyond what are known as purely governmental functions. It should be said, however, that Lord Avebury, although strongly opposed to all forms of "municipal trading," does recognize the desirability of doing some things at municipal expense for the uplift of the people.

It is hardly necessary to take up either book in detail. Neither one, within the space used, omits any fact or argument against municipal ownership afforded by British experience. Mr. Porter goes further and devotes a chapter to Russia as an object lesson in the destruction of individuality through a bureaucracy, and another chapter to Australasia as an example of a "failure of an attempt to blend democracy and bureaucracy." Each author discusses the personnel and the responsibilities of British local authorities, the rapid increase in local debts, the labor question in its various phases, alleged fictitious profits of municipal ownership, and each attempts to show how municipal ownership has retarded industrial and urban development, particularly the telephone, electric lighting, power and street railway services. To a considerable extent each author traverses much the same ground as was covered a little earlier by Prof. Hugo R. Meyer, in his "Municipal Ownership in Great Britain" (see our issue of Aug. 16, 1906), but while Lord Avebury frequently quotes Mr. Meyer approvingly, we remember no reference to that author by Mr. Porter, and his index, which is quite full, does not contain Mr. Meyer's name.

As has been intimated, none of the arguments in favor of municipal ownership are presented by either author, except for purposes of refutation. When comparisons are made between electrical development in Great Britain and the United States no allowances are made for differences in local conditions, traditions and prejudices. In discussing the increase of municipal debt no mention is made of the fact that the services for which the debt has been incurred were or would have been rendered by private if not by public capital, and that in either case capital charges must be met by the users of those services.

Finally, there is much, very much, in each book that deserves careful attention by both the friends and foes of municipal ownership, no matter under what flag they live. This is particularly true of some of the statements regarding the unsatisfactory character of municipal accounting. Each book, as well as the one by Mr. Meyer, previously mentioned, is far more readable and useful than the large treatise by Major Leonard Darwin ("Municipal Trade," see our issue of Feb. 18, 1904), which, up to last year, was practically the only book against municipal ownership.

AN EXTENSION OF THE DEWEY DECIMAL SYSTEM OF CLASSIFICATION APPLIED TO THE ENGINEERING INDUSTRIES.—By L. P. Breckenridge and G. A. Goodenough. Bulletin No. 9, University of Illinois Engineering Experiment Station. Urbana, Ill.: The University. Paper; 6 × 9 ins.; pp. 72.

It is acknowledged among engineers that a well-ordered card index is a valuable asset. Not only does it collect and select necessary items of information which otherwise might be lost in the maze of literature, but the training and mental exercise in the assorting and dividing of these bits of information impresses on the memory many things which the mind in the ordinary course of business would forget. As Carlyle said, "A book without an index is a ship without a rudder," so an index whose sub-divisions are not systematically and thoroughly arranged is of less good than no index at all, for in the latter case no time is wasted in trying to find references which are buried deep in the midst of some unrelated subject.

To help the engineer in classifying his index, an extension of the decimal classification system devised by Mr. Melvil Dewey has been made by the authors of the above named book. This system has reduced indexing to its lowest terms and the special adaptation here made to engineering subjects will help every engineer who is trying to build up his own pocketbook. It is to be regretted that the authors did not call in some of their associates in the civil engineering field to help in the classifications in that line of work. It would have added greatly to the value of the last pages. The classifications under concrete and reinforced concrete are of small value. The mechanical and electrical engineering divisions are remarkably complete.

PROBLEMS OF THE PANAMA CANAL.—Including Climatology of the Isthmus, Physics and Hydraulics of the River Chagres, Cut at the Continental Divide and Discussion of Plans for the Waterway, with History from 1890 to Date. By Brig.-Gen. Henry L. Abbot, U. S. Army Retired. New York: The Macmillan Co. London, England: Macmillan & Co., Ltd. Cloth; 5¾ × 8¾ ins.; pp. 269; 8 plates and 15 text figures. $2, net.

The first edition of this book appeared about two years ago, before the final determination was made of the type of construction to be adopted at Panama. In the present edition, General Abbot brings the work up to the beginning of 1907 by the addition of a chapter dealing with the history of the work since the United States assumed control in 1904.

As most of our readers will recall, General Abbot was a member of the Board of Consulting Engineers which reported on the type of canal; and he was one of those favoring the lock type of canal. The book contains, therefore, considerable information showing the reasons which led to the selection of the lock type. The concluding sentence of the book is noteworthy:

> With abundant financial resources and unlimited time for construction, it may be considered "feasible" from an engineering point of view to construct a sea level canal; but when completed it must always remain inferior as a transit route to the "lake" type adopted.

The book is thus far the only reliable technical account of the Panama Canal enterprise available to those who will not undertake the task of searching through the files of the engineering journals for the articles there published recording the successive stages of the work.

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The Hydrometallurgy of Silver.

Reviewed by BRADLEY STOUGHTON.*

HYDROMETALLURGY OF SILVER.—With Special Reference to Chloridizing Roasting of Silver Ores and the Extraction of Silver by Hyposulphite and Cyanide Solutions. By Ottokar Hofmann, M. Am. Inst. M. E. New York and London: Hill Publishing Co. Cloth; 6 x 9¼ ins.; pp. 345; 83 illustrations, mostly in the text. $4.

The book is divided into two parts, of which the first deals with chloridizing roasting of silver ores (154 pages), the second with the extraction of the silver (174 pages). The author points out in the preface that in the hydrometallurgical process for the extraction of silver from complex sulphide ores, the final result depends entirely on the quality of the roasting. He has therefore devoted the first half of the book to chloridizing roasting as follows: Theory of chloridizing roasting; Crushing the ore; Percentage of salt required; Loss of silver by volatilization; Methods of roasting; Consumption of fuel; Reverberatory furnaces worked by hand; Mechanical roasting furnaces; Collecting the flue-dust; Sulphatizing roasting; Chloridizing of argentiferous zinc-lead ore; Chloridizing of calcareous ores.

The account is simply and clearly written and gives the results obtained by the author at Yedras, Sinaloa, Mexico, at the San Francisco del Oro, and other Chihauhua mines, the Silver King, Arizona, and elsewhere. It therefore has the advantage of being written in the main from personal experience and not culled from the writings of others. Tables and figures of the results obtained in various experiments add to the value of this part of the book.

Part II. deals with Lixiviation with sodium hyposulphite; Precipitation of silver; Treatment of the precipitate; Construction of troughs; Trough lixiviation; Russell and Kiss Processes; The Augustin Process; Extraction with sulphuric acid; The Ziervogel Process; Treatment of silver ores rich in gold; Cyanidation of auriferous silver ores.

Hofmann himself introduced the method of hypoleaching into Mexico in 1868. He gives an account of work at Sombrerete, Zacatecas; Cusihuiriachic, Chihuahua, Mexico and at Silver King, Arizona, etc. Under the heading of the Sulphuric Acid Process the old method as used at Freiberg, Saxony, is briefly described, and then follows the Hofmann method with a description of its use at the works of the Consolidated Kansas City Smelting and Refining Co., Argentine, Kan., in the treatment of the argentiferous plumbiferous copper matte whereby 60 tons of blue vitriol were produced daily.

The section on the Cyanidation of auriferous silver ores comprises abstracts of several papers, notably that of Oxnam of the Palmarejo & Mexican Gold Fields, Ltd., Chinipas (Transactions of the American Institute of Mining Engineers, May, 1905). A trifle more than a page each is devoted to the Augustin and the Ziervogel Processes.

With the exception of the hyposulphite method the sections in Part II. are not equal to those of the first part. After the Augustin Method, we should have liked to see a description of the application of the Claudet Process to burnt pyrites, etc., whilst in the Ziervogel, we had looked for some account of the work at Argo, Denver. The subject of Cyanidation of Silver ores seems to us to be of the utmost importance and a somewhat longer introduction to the process would have been timely.

On the whole, the book is well written, in an easy and interesting, style, and even if the hyposulphite method has seen its day, this volume will be read with interest. A good index is given and the printing and binding are of the same high standard as the other books of the Hill Publishing Co.

THE TELEPHONE SITUATION IN THE CITY OF CHICAGO.—Report in Respect to Service, Rates, Regulation of Rates, etc., Submitted to the Committee on Gas, Oil and Electric Light of the City Council of the City of Chicago by a Special Commission (George W. Wilder, Secy.). April, 1907. Chicago, Ill.: Pub. Doc. Paper; 8 x 11¼ ins.; pp. 124; illustrated.

*Adjunct Professor, Department of Metallurgy, Columbia University, New York City.

HANDBUCH FUR EISENBETONBAU.—Edited by F. von Emperger. Vol. III. Engineering Structures: Part 1. Prepared by F. von Emperger, A. Nowak and F. W. Otto Schulze. Berlin, Germany: Wilhelm Ernst & Son. Paper; 7¼ x 10½ ins.; pp. 330; 4 folding plates and 547 text illustrations. 15 marks; American price, $6.

The volume before us, though lettered "Volume III.," is evidently the first published part of a projected work of large scope. The purpose of the work, whose general direction is in the hands of Mr. F. von Emperger, seems to be practically identical with that of existing books on reinforced concrete, except that a fuller, more voluminous treatment is planned for. For instance, this first volume, with its 330 pages of text, covers only two fields: (1) foundations and walls, (2) dams, river and harbor structures and the like. A characteristic of the plan adopted by the editor is to have each section written by a special contributor. Undoubtedly the idea is commendable, and its results are excellent for the most part. The present volume was written in three such sections. Each includes a discussion of the considerations involved in designing the structures described. The main part of the space, however, is devoted to description and illustration of actual structures; much industry on the part of the authors in compiling from periodical literature drawings and descriptions of work done in various parts of the world is evidenced. The book as a whole derives its value entirely from this feature, and may therefore be called a descriptive album of reinforced-concrete construction. As concerns the English-speaking reader, the first and second of the three parts are much decreased in utility by the omission of titles from the illustrations. However, the authors apparently do not have the foreign reader in mind, but base their work on the purpose of giving to German literature a descriptive treatise comparable to those with which French and English-speaking engineers are already provided.

A RECONNAISSANCE OF THE BALTIMORE AND ROCHESTER FIRE DISTRICTS.—With Some Illustrations and Excerpts from Opinions No Less Authoritative than Significant. (By E. S. Hand, Installation Engineer, Mississippi Wire Glass Co., 277 Broadway, New York.) Cloth; 5¾ x 9¼ ins.; pp. 87; illustrated.

The Baltimore and Rochester conflagrations will long remain—we hope—the best object lessons of the behavior of modern materials of construction under severe test by fire available to the engineer. While the San Francisco fire was of far greater extent and severity, it was complicated by the earthquake damage.

The volume before us gives a very interesting record of these great fires and preserves in permanent form much information scattered through volumes of technical journals and daily papers.

STATE ENGINEER OF OREGON.—First Biennial Report to the Governor, for the Years 1905-1906. (John H. Lewis, State Engineer.) Salem, Ore.: Pub. Doc. Cloth; 5¾ x 9 ins.; pp. 108; folding and other plates.

Oregon has joined the already quite large number of Western States in the creation of the office of State Engineer. The chief duties of this official in Oregon, as elsewhere in the West, are connected with irrigation development, and particularly the apportionment of water therefor. This report deals with the office and field work of the State Engineer since early in 1905. An abstract of the water laws of other States and countries is given, and also the results of various stream gagings.

THE SIX-CHORD SPIRAL.—By J R. Stephens, C. E. New York: The Engineering News Publishing Co. Cloth; 5 x 7½ ins.; pp. 68; six illustrations in the text. Cloth, $1.25, net; boards, $1.00, net.

The following extracts from the preface explain the subject and nature of the work:

The six-chord spiral is an ordinary multiform compound curve of six arcs of equal length, whose degrees of curvature increase in the order of the natural numbers, and so arranged that the seventh arc always exactly coincides with the main circular curve. * * * It is perfectly flexible and always fits. * * * The method is quickly grasped, memorised and applied by transitmen with no previous knowledge of spirals, being based on what they already know; the mathematical treatment being elementary throughout.

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TRACY.—PLANE SURVEYING.

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The Decline of the English Fire Arms Industry.

THE CAUSES OF DECAY IN A BRITISH INDUSTRY.—By "Artifex" and "Opifex." London, New York and Bombay: Longmans, Green & Co. Cloth; 5¼ × 8¾ ins.; pp. 296; illustrated. $2.50, net.

The business man sometimes goes into print with an account of the reasons for his success, when he has reached a point where others cannot profit to his loss by such knowledge; but it is indeed a rare thing when he enters into a discussion of the whys and wherefore of his failure. The pride of Birmingham is its manufacturers, and for many years in the forefront of them all was the ancient and honorable profession of making arms, for defense and offense; first as swords and pikes and then as guns and pistols. There was a time when the British ruled the world in this particular industry; now they are the followers of the Belgians and Americans. The anonymous authors of the above-named book are two manufacturers of firearms at Birmingham, men who started in at the bottom of the trade and worked to the head, only to see it slipping from their fingers. They have certain fixed ideas as to the exact causes of the fall of their industry, and the pages of this book contain them in concise and readable form. In fact, if every economic treatise was written in so interesting and epigrammatic a style, the study of economics would be a much easier task.

The authors claim that the two big causes for the falling off in this trade are: (1) The policy of the English government in not protecting in any way the industry; and (2) the reluctance of the British manufacturer to enter into competition with the so-called "modern business methods" of foreign manufacturers. The antagonism displayed against the governing class or party of Great Britain is worthy of our most partisan newspapers in the heat of a presidential campaign. The well-known territorial ambitions of England are epitomized as follows:

> He [the British manufacturer] will see the British Foreign Office stolid and inert when confronted with the increased imposts Russia, Spain and Japan are about to levy on English manufactures, but in a pother of trepidation about the removal of some old boundary stones in the desert peninsula of Sinai!

Throughout the book the charge is made and repeated that the government, in its policy of free trade and by special enactments directly opposing the firearm interests, has put obstacles in the path of the manufacturers instead of aiding them. In addition to this official hindrance the British merchant and manufacturer is constitutionally opposed to entering into what to him is undignified competition. He makes his goods the best he knows how, which is as a rule as good as they can be made, and he sells them at a fair profit. If anyone wants to buy he should do so on the merits of the goods and not because they are widely advertised, look pretty and gaudy or because the selling agent happens to be of a glib tongue. Competition under these conditions with the advanced German or American could but result in one end. The British industry, though still making fine goods and selling at a reasonable rate, has gradually declined.

Engineers are not as a rule interested in such a study as this, but to the manufacturing engineer, who is making a product which has to compete in the markets of the world, this remarkably well-written book, though without doubt prejudiced and partial in many of its statements, will repay the time and trouble of reading.

ANLAGE VON FABRIKEN.—By H. Haberstroh, E. Weidlich, E. Gorts, and Dr. R. Stegemann. Leipzig, Germany: B. G. Teubner. Paper; 6½ × 9¼ ins.; pp. 528; folding plates and numerous text illustrations. 12 marks; American price, $4.80.

This work is a guide and a compendium of suggestions to the manufacturer contemplating the erection or extension of his plant. It discusses in very condensed form the factors concerned in general location and layout, in the planning and construction of the buildings and their accessory plant, in the equipment, and in welfare provision for employees. Each of the four sections is written by a different author. The book may be useful to American students of the subject as throwing light on German views of factory planning.

MUNICIPAL CONTROL OF PUBLIC UTILITIES.—A Study of the Attitude of Our Courts toward an Increase of the Sphere of Municipal Activity. By Oscar Lewis Pond, LL. B., Ph. D., Member of the Indianapolis Bar. Vol. XXV., No. 1, Studies in History, Economics and Public Law, Edited by the Faculty of Political Science of Columbia University. New York: Columbia University, The Macmillan Co., Agents. Paper: 6½ × 10 ins.; pp. 115. $1.

The author has produced in brief compass an outline of constitutional limitations and court decisions bearing upon the municipal control of public service corporations. He begins with the definition of the purely governmental and the private or business functions of municipal corporations, discusses the legal construction of municipal charters and the implied powers of municipal corporations. He then sets forth "municipal purposes within the meaning of the constitution," shows the grounds on which municipal property is exempted from taxation, and treats of the sale of municipal property, power to grant exclusive franchises, and the regulation of charges for services rendered by private corporations. The author shows himself to be in favor of the municipal side of the questions involved.

THE COMPLETE AUTOMOBILE INSTRUCTOR.—Over Six Hundred Questions with Answers and Illustrations, Covering the Principle, the Operation, and the Care of Gasoline Automobiles. By Benjamin R. Tillson, Director of the H. J. Willard Co. Automobile School. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4 × 7 ins.; pp. 213; 49 illustrations in the text. Cloth, $1.50; morocco, $2.

As a companion for the man who drives his own machine to have at all times in his pocket or near at hand this book fills a growing want, in view of the constantly increasing number of owners who either cannot afford the services of an expert chauffeur or from preference wish to do their own driving.

The arrangement of the contents—the questions all in the fore part of the book and the answers in the back—while not perhaps the most convenient for studying the subject as a whole, is very well adapted to use on the road. For example, the novice gets into trouble with his motor; having the book at hand, he may look up, in the question portion, the particular unruliness which the machine has developed, then turn to the answer—a convenient cross-reference system facilitating this—and apply the remedy there found. Thus the possession of the book obviates the necessity for the new car owner's "cramming" with a mass of befuddling details at the outset, and enables him gradually to acquire a working knowledge of his machine as necessity demands it.

Questions and answers on various accessories, tires, batteries, lubricants, etc., supplement valuably the matter more particularly pertaining to the motor and transmission. A short chapter on alcohol as a source of power is of timely interest. The size of the volume makes it especially suitable for carrying in the pocket. The illustrations are of such a character as clearly to illustrate the text, even to a novice.

HOW TO CHECK ELECTRICITY BILLS.—Methods of Charging for Electricity with Directions for Reading and Testing Electric Meters. By S. W. Borden. New York: McGraw Publishing Co. Cloth; 4¼ × 6¾ ins.; pp. 54; 41 illustrations in the text. 50 cts., net.

The first part of this little volume is given over to a non-technical definition of a watt, by considering how many watts the common forms of apparatus use. Chapters are included on general principles of meters, troubles and systems of charges and discounts. The part on meter dials may seem absurdly simple to an engineer, but to a person of little mathematical education the discussion on properties of figures would seem confusing. If a statement made later, had been a bit amplified, this might have been more readily cut out. That statement was, that the first pointer on a meter dial makes one revolution for every ten units used and registers units, that the second pointer makes a revolution for each hundred units of power and registers in tens of units, etc. That the unit of the dial was not necessarily a watt could have been clearly established. The portions on readings and reduction of readings to KW. hours is very practical.

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THE ENGINEERING INDEX ANNUAL FOR 1906.—Compiled from The Engineering Index published monthly in "The Engineering Magazine" during 1906. New York and London: The Engineering Magazine. Cloth; 6½ × 9½ ins.; pp. 395. $2.

For the first time since it was begun by Prof. J. B. Johnson, the Engineering Index appears as a one-year's volume. The last preceding issue covered five years, 1901-1905 inclusive, and with the three earlier volumes covered a total period of 22 years. With the present fifth volume it has been found necessary to make the issue an annual one. The size of the volume under review suggests that this plan was unavoidable. [In comparing with previous volumes, however, it is to be noted that the present one uses much larger type.]

A more radical departure appears in the make-up of the volume. In the previous issues, alphabetical arrangement of all items, or rather of the subject headings, was employed as the basis of assemblage; for example, in the volume 1901-1905, "Coherer," with 16 items, was followed by "Coinage," with 4 items, and this by "Coke," with 30 items and numerous cross-references, then "Coke Breeze," etc. In the present annual volume all items have been grouped according to eight grand divisions; Civil Engineering; Electrical Engineering; Industrial Economy; Marine and Naval Engineering; Mechanical Engineering; Mining and Metallurgy; Railway Engineering; Street and Electric Railways. Each of these is subdivided into a number of heads, for example Railway Engineering into: Conducting Transportation; Motive Power and Equipment; New Projects; Permanent Way and Buildings; Traffic; Miscellany. So far the classification is of arbitrary arrangement. A set of sub-heads, under the above-noted main heads, exhibits alphabetical grouping, and finally the individual entries are alphabetically arranged under the sub-heads. These sub-heads correspond to the subject headings in the earlier volume. Thus, the subject-heading "Coherer" now would appear under head "Communication" in the division "Electrical Engineering"; "Coinage" would appear in the division "Industrial Economy"; and the items on "Coke" would appear scattered under the heading "Coal and Coke" in the division "Mining and Metallurgy."

This change from an unclassified to a highly segregated arrangement of subjects is interesting especially because the increasing bulk of technical literature and the interweaving of its former distinct fields has in recent years given rise to a marked tendency away from such grouping, and is making constantly more difficult the task of grouping an index or bibliography of engineering. However, the adoption of the grouped plan at this time in the case of the "Engineering Index" means nothing more than that the labor of issuing the volume was greatly simplified thereby. The monthly issues of the Index (in "The Engineering Magazine") are in grouped arrangement and the combination of many such issues into a volume of ungrouped arrangement involved the very expensive and tedious undertaking of re-editing the entire mass of items. As the issue of such an index is not a highly profitable business at best, the present plan was adopted, permitting the matter already published in monthly instalments to be assembled at little cost and with minimum delay.

The enterprise of the publishers in undertaking the prompt issue of the annual volume is to be commended. It makes available to the reader a guide to a very extensive circle of periodical engineering literature down to about 6 months before the date of issue of this volume.

It is unfortunate in some respects that this volume, purporting to cover the year 1906, fails to include many items that appeared in the last three months of the year and on the other hand includes many articles published in the latter part of 1905. This of course is because the volume is made up from the monthly Index published during 1906, and is evidently unavoidable without laborious selection and recombination. Moreover, in a continuous series of similar annual index volumes the defect practically disappears.

We trust the Index Annual will meet with a reception that will ensure its permanence.

THE DISINFECTANT VALUE OF CHLORINE.—A Series of Articles on the Application of Chlorine (in its various states) to Disinfecting Purposes, with Elaborate Tests of Efficiency, a Complete Glossary of Technical Terms, etc. (Reprinted from "The Public Health Engineer.") London, England: The Public Health Engineer. Cloth; 8¾ × 7 ins.; pp. 62.

The first and longest of the various papers and excerpts making up this book is one by Dr. Schumacher, of the Institute of Hygiene, Hamburg, Germany, on "The Disinfectant Value of Chloride of Lime." This paper describes in detail, with numerous tables of analyses, experiments made on sewage. Initial work was done on a small scale in a laboratory, but in addition several tanks receiving sewage from hospitals were studied quite extensively. The author concludes that very good bacterial results can be obtained by chloride of lime in the ratio of 1 to 2,000, and fair results, under some circumstances, with 1 to 5,000. Our readers will readily appreciate that the treatment of sewage on a large scale by such a plant would be generally prohibited, inasmuch as at the higher rate some 30 grains per U. S. gallon would be required. Even taking the lesser unit quantity and reducing this somewhat on account of the relative weakness of American sewage, the cost would still be prohibitive, unless under exceptional circumstances. Two other papers, of no little interest and some possible value to engineers, describe attempts to sterilize public water supplies by chloride of lime, in each case after outbreaks of typhoid fever. At Maidstone, England, the water mains were filled with a solution of chloride of lime, and at Lincoln, England, the same agent was employed in two service reservoirs. Other papers in the book treat of disinfection for tuberculosis germs and for other purposes.

Publications Received.

AMERICAN ELECTRIC RAILWAY PRACTICE.—By Albert B. Herrick, Consulting Engineer, and Edward C. Boynton, General Manager of the Orange County Traction Co. New York: McGraw Publishing Co. Cloth; 6 × 9½ ins.; pp. 403; 223 illustrations, mostly in the text. $3, net.

AMERICAN PUBLIC WORKS ASSOCIATION.—Second Convention, Atlanta, Ga., Sept. 14 and 15, 1906. (Edward J. O'Beirne, Chairman Executive Committee, 821 Empire Building, Atlanta, Ga.) Cloth; 6 × 9 ins.; pp. 183; illustrated.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.—Proceedings, 1906. Containing a Complete Report of the 25th Annual Convention, Held at the State Fair Grounds, Columbus, O., Oct. 17, 18, 19, 1906. New York: The Association (Bernhard V. Swenson, Secy., 29 West 39th St.). Paper; 6 × 9 ins.; pp. 472; illustrated.

AMERICAN STREET AND INTERURBAN RAILWAY ACCOUNTANTS' ASSOCIATION.—Proceedings, 1906. Containing a Complete Report of the Tenth Annual Convention, Held at the State Fair Grounds, Columbus, O., Oct. 16, 17, 18, 1906. Birmingham, Ala.: The Association (Elmer M. White, Secy., 2019 Thirteenth Ave., South). Paper; 6 × 9 ins.; pp. 351.

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION.—Proceedings, 1906. Containing a Complete Report of the Fourth Annual Convention Held at the State Fair Grounds, Columbus, O., Oct. 15, 16, 17, 1906. London, Ont.: The Association (S. W. Mower, Secy., General Manager Southwestern Traction Co.). Paper; 6 × 9 ins.; pp. 255; illustrated.

ASSOCIATION FOR THE PROTECTION OF THE ADIRONDACKS.—Sixth Annual Report of the Hon. Henry E. Howland, President. Including a Brief Summary of Reasons Why Section 7 of Article VII. of the Constitution Should Not Be Amended, Extracts from Preliminary Reports of the Association's Engineers, and Testimony Concerning Unsanitary Conditions Produced by Storage Reservoirs in the Adirondacks. Paper; 5¾ × 9 ins.; pp. 30.

THE BACTERIOLOGICAL EXAMINATION OF WATER-SUPPLIES.—By William G. Savage, B.Sc., M.D. (Lond.), D.P.H., Medical Officer of Health and Public Analyst, Colchester (England). Philadelphia, Pa.: P. Blakiston's Son & Co. Cloth; 5 × 8¼ ins.; pp. 297; 1 folding plate and 13 text illustrations. $2.50, net.

CEMENT AND CONCRETE.—By Louis Carlton Sabin, B.S., C. E., M. Am. Soc. C. E., Assistant Engineer, Engineer Department, U. S. Army. Second Edition, revised and enlarged. New York: McGraw Publishing Co. Cloth; 5¾ × 9¼ ins.; pp. 572; illustrated, $5, net.

THE COMMON BACTERIAL INFECTIONS OF THE DIGESTIVE TRACT.—And the Intoxications Arising from Them. By C. A. Herter, M.D., Professor of Pharmacology and Therapeutics in Columbia University, Consulting Physician to the City Hospital, New York. New York: The Macmillan Co. London, England: Macmillan & Co., Ltd. Cloth; 5 × 8 ins.; pp. 380. $1.50, net.

CONTRIBUTION A L'ETUDE DES ARGILES ET DE LA CERAMIQUE.—By Messrs. Chantepie, Chapuy, Coupeau, Damour, Lavezard, Laville, Le Chatelier, Granger, Holborn, Hecht, Saglio, Sherzer, Vogt, Wien, Zschokke. Paris, France: La Societe d'Encouragement pour l'Industrie Nationale (Rue de Rennes, 44). Paper; 9 × 11 ins.; pp. 626; numerous text illustrations.

DESIGN AND CONSTRUCTION OF HYDROELECTRIC PLANTS.—Including a Special Treatment of the Design of Dams. By R. C. Beardsley. New York: McGraw Publishing Co. Cloth; 6 × 9½ ins.; 480 illustrations in the text, and 76 tables.

ELECTRIC LIGHT WIRING.—By C. E. Knox, Am. Inst. E. E. New York: McGraw Publishing Co. Cloth; 6 × 9½ ins.; pp. 219; 119 illustrations, mostly in the text. $2, net.

ELECTRIC RAILWAYS.—A Series of Papers and Discussions Presented at the International Electrical Congress in St. Louis, 1904. Republished by the McGraw Publishing Co., New York, by Special Arrangement with the International Electrical Congress. Cloth; 6 × 9½ ins.; pp. 447; illustrated. $3, net.

ELECTRIC AND MAGNETIC MEASUREMENTS AND MEASURING INSTRUMENTS.—By Frank W. Jones, M. E., M. Am. Inst. E. E. New York: McGraw Publishing Co. Cloth; 6 × 9¼ ins.; pp. 398; 312 illustrations in the text. $3.50, net.

ELECTRICITY IN HEALTH AND DISEASE.—Edited by S. H. Monell, Editor "Journal of Treatment," and of "A System of Instruction for Physicians in Methods and Medical Uses of Light, Hot-Air, Vibration and High-Frequency Currents," etc. New York: McGraw Publishing Co. Cloth; 6 × 9¼ ins.; pp. 321; illustrated. $3, net.

EXPERIMENTAL AND THEORETICAL APPLICATIONS OF THERMODYNAMICS TO CHEMISTRY.—By Dr. Walther Nernst, Professor and Director of the Institute of Physical Chemistry in the University of Berlin. New York: Charles Scribner's Sons. Cloth; 5¼ × 8¼ ins.; pp. 123; eight illustrations in the text and 23 tables. $1.25, net.

FINANCING AN ENTERPRISE.—A Manual of Information and Suggestion for Promoters, Investors and Business Men Generally. By Francis Cooper. In Two Volumes. New York: The Ronald Press. Cloth; 5¼ × 8¼ ins.; pp. 543. $4; either volume singly, $2.

FIRE ASSAYING.—A Practical Treatise on the Fire Assaying of Gold, Silver and Lead, Including Description of the Appliances Used. By Evans W. Buskett, B.S., Chemist, Ozark Smelting and Mining Co., Coffeyville, Kans. New York: D. Van Nostrand Co. Cloth; 5 × 7½ ins.; pp. 105; 70 illustrations in the text and numerous tables. $1.25, net.

LOCOMOTIVE BREAKDOWN QUESTIONS.—Answered and Illustrated. By W. G. Wallace, Past-President Traveling Engineers' Association. Chicago, Ill.: Frederick J. Drake & Co. Flexible leather; 4½ × 7 ins.; pp. 285; text illustrations and folding plates. $1.50, net.

LOCOMOTIVE COMPOUNDING AND SUPERHEATING.—A Practical Text-Book for the Use of Railway and Locomotive Engineers, Students and Draftsmen. By J. F. Gairns. London, England: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co. Cloth; 5¼ × 8¾ ins.; pp. 189; 1 plate and 148 text illustrations. $3, net.

MASSACHUSETTS HIGHWAY COMMISSION.—Annual Report for the Fiscal Year Ending Nov. 30, 1906. (W. E. McClintock, Chairman Commission.) Part I. State Highways and Motor Vehicles. Part II. Supervision of Telegraph and Telephone Companies. Boston, Mass.: Pub. Doc. (No. 54). Cloth; 5½ × 9 ins.; pp. 135; two plates and one folding map.

THE MECHANICS OF HOISTING MACHINERY.—Including Accumulators, Excavators and Pile-Drivers. Text-Book for Technical Schools and a Guide for Practical Engineers. By Dr. Julius Weisbach and Prof. Gustav Herrmann. Authorized Translation from the Second German Edition by Karl P. Dahlstrom, M.E., Late Instructor of Mechanical Engineering at the Lehigh University. New York: The Macmillan Co. London, England: Macmillan & Co., Ltd. Cloth; 5½ × 9 ins.; pp. 332; 177 illustrations in the text. $3, net.

MODERN AMERICAN MACHINE TOOLS.—By C. H. Benjamin, M. Am. Soc. M.E., Professor of Mechanical Engineering, Case School of Applied Science, Cleveland, O. New York: E. P. Dutton & Co. Cloth; 5½ × 9 ins.; pp. 320; 134 illustrations in the text. $5, net.

SEWAGE AND THE BACTERIAL PURIFICATION OF SEWAGE.—By Samuel Rideal, D.Sc. (Lond.), Author of "Water and its Purification" and "Disinfection and the Preservation of Food." Third Edition. London, England: The Sanitary Publishing Co., Ltd. New York: John Wiley & Sons. Cloth; 6 × 9¼ ins.; pp. 355; 58 illustrations, mostly in the text. $4.

SOME TENDENCIES OF THE COLLEGE OF TECHNOLOGY.—By Henry Smith Prichett, Ph.D., LL.D. (Reprinted from Clarkson Bulletin, Vol. IV., No. 1, January Supplement.) Potsdam, N. Y.: Thos. S. Clarkson Memorial School of Technology. Paper; 6 × 9 ins.; pp. 17.

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